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ABSTRACT

Developed in Virginia, this publication contains task analysis guides to support selected tech prep programs that prepare students for careers in the engineering, trade, and technical cluster. Three occupations are profiled: drafting and design technology, precision machining technology, and electronics technology. Each guide contains the following essential elements: (1) an occupational task list derived from a panel of local workers or employers (occupational analysis); (2) a list of courses and programs that make up the tech prep program; (3) a collection of secondary and postsecondary instructional objectives and performance measures that reflect the occupational analysis; and (4) a list of resources that can be used to support instruction. The task lists are comprised of a duty area, a task or competency, a performance objective, a performance measure, and enabling objectives and activities. (KC)

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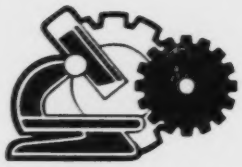
TASK ANALYSES

ENGINEERING, TRADE, AND TECHNICAL CLUSTER

ED 406 542

Drafting and Design Technology



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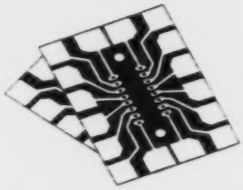

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TASK ANALYSES
ENGINEERING, TRADE, AND TECHNICAL CLUSTER

DRAFTING AND DESIGN TECHNOLOGY
PRECISION MACHINING TECHNOLOGY
ELECTRONICS TECHNOLOGY

DEVELOPED BY

Crossroads Educational Consortium

PRODUCED BY

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FOR

Commonwealth of Virginia
Community College System
101 North 14th Street
Richmond, Virginia 23219

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INTRODUCTION

This publication contains task analyses guides to support selected Tech Prep programs that prepare students for careers in the Engineering, Trade, and Technical cluster.

Tech Prep curriculum guides are essentially local products, developed to support programs offered by a community college and the school divisions in its consortium. Each guide is intended to serve as a model for other sites that wish to establish a similar program, and for this reason, all deliverables as they are received are placed in the library of the Virginia Vocational Curriculum and Resource Center (VVCRC), available on loan. A few have been selected for publication and broader distribution by the Virginia Community College System, based on their potential for widespread use.

Each task analyses guide included in this publication has the following essential elements:

- An occupational task list derived from a panel of local workers or employers (occupational analysis)
- A list of courses and programs that make up the Tech Prep program.
- A collection of secondary and postsecondary instructional objectives and performance measures that reflect the occupational analysis
- A list of resources that can be used to support instruction

Certain other elements, such as related academic skills and career path information, have been included if developed by the local site. Other information, including learning activities, sample student schedules, course descriptions, and other introductory matter, may be obtained from the complete guide in the VVCRC library or from the project director.

Each task analyses guide has been reviewed and approved for statewide use in secondary schools by the appropriate content specialist at the Virginia Department of Education. Due to recent restructuring of many secondary program areas, the content of a Tech Prep guide, based on local employment requirements, may differ from the VDOE-recommended course content. Suggestions by the content specialist to reconcile these differences may be noted in the guide.

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TASK ANALYSES

ENGINEERING, TRADE, AND TECHNICAL CLUSTER

Drafting and Design Technology

A COMPETENCY-BASED CURRICULUM GUIDE

DEVELOPED BY

Crossroads Educational Consortium
Bland County Public Schools
Carroll County Public Schools
Grayson County Public Schools
Smyth County Public Schools
Wythe County Public Schools
Galax City Schools
Wytheville Community College

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OCCUPATIONAL ANALYSIS

Occupational Task List: Drafting and Design Technology

A. DEVELOPING BASIC LAB SKILLS
- Demonstrate use of drafting equipment and supplies.
- Reproduce drawings.
- Demonstrate freehand lettering techniques.
- Demonstrate line drawing techniques.

B. CONSTRUCTING GEOMETRIC FIGURES
- Draw straight lines.
- Construct angles.
- Construct plane figures.
- Construct circles and arcs.
- Construct irregular figures.

C. DRAWING ORTHOGRAPHIC PROJECTIONS
- Sketch orthographic projections.
- Draw multiview projections.
- Draw auxiliary views.

D. DRAWING SECTIONS
- Draw standard sections.
- Draw special sections.
- Draw conventional breaks.

E. DRAWING PICTORIALS
- Draw axonometric projections.
- Create oblique drawings.
- Create presentation drawings.
- Draw exploded isometric assemblies.

F. USING DIMENSIONING TECHNIQUES
- Demonstrate dimensioning techniques.
- Interpret and apply tolerances.
- Apply geometric tolerances.

G. DEMONSTRATING BASIC COMPUTER-AIDED DESIGN SKILLS
- Demonstrate basic computer skills.
- Set drawing parameters.
- Create drawing entities.
- Edit drawing entities.
- Control viewing.
- Use drawing aids.
- Save drawing files.
- Control layers and linetypes.

H. CONSTRUCTING MACHINE DRAWINGS
- Draw working drawings.
- Draw fasteners.

I. PREPARING ARCHITECTURAL PLANS
Draw and dimension a floor plan.
Draw a foundation plan.
Draw exterior elevation plans.
Draw door and window schedules.
Draw sections.
Draw an electrical plan.
Draw a plumbing plan.
Create a presentation design.

J. DEMONSTRATING CIVIL AND SURVEY DRAFTING TECHNIQUES
Demonstrate use of a transit.
Generate mapping drawings.

K. CONSTRUCTING ELECTRICAL AND ELECTRONICS DRAWINGS
Identify electronic symbols.
Construct schematic diagrams.

L. CONSTRUCTING HYDRAULIC AND PNEUMATIC POWER DRAWINGS
Construct hydraulic diagrams.
Construct pneumatic diagrams.

M. CONSTRUCTING SPUR AND BEVEL GEAR DRAWINGS
Construct detail spur gear drawings.
Construct detail bevel gear drawings.

N. DESIGNING MECHANICAL DESIGN PROJECT
Plan a mechanical design project.
Design a mechanical part or parts.

O. DEMONSTRATING ADVANCED COMPUTER-AIDED DESIGN SKILLS
Develop three dimensional drawings.
Develop solid model drawings.

PROGRAM DESIGN

Secondary Course Offerings

Drafting I (grade 11)
Drafting II (grade 12)
English 9-12
Algebra I and II
Probability and Statistics
Lab Sciences 9, 10, 11
World Studies
United States and Virginia History
United States and Virginia Government
Health and Physical Education 9 and 10
Vocational Electives

Postsecondary Course Requirements (two years of courses at the community college level)

ENG 101: Practical Writing
MTH 113-114: Engineering Technical Math I & II
PHY 201: General College Physics I
SPD 100: Principles of Public Speaking
HLT 160: Personal Health and Fitness
STD 100: College Orientation
DRF 121: Mechanical Drafting I
DRF 127: Geometric Tolerancing
DRF 151-152: Engineering Drawing Fundamentals I & II
DRF 201-202: Computer Aided Drafting and Design I & II
DRF 211: Advanced Technical Drafting I
DRF 216: Advanced Technical Drafting II
EGR 105: Introduction to Problem Solving in Technology
EGR 130: Statistics and Strength of Materials for Engineering Technology
IND 113: Materials and Processing in Manufacturing I
MAC 131: Machine Laboratory I
MEC 119: Introduction to Basic CNC-CAM
ARC 251: Architectural Drawings I
DRF 298: Seminar and Project in Drafting

DUTY AREA 1. DEVELOPING BASIC LAB SKILLS

1.1 Demonstrate the use of drafting equipment and supplies.
1.2 Reproduce drawing.
1.3 Perform freehand lettering technique.
1.4 Demonstrate line drawing technique.

DUTY AREA
1. DEVELOPING BASIC LAB SKILLS

COURSE
Drafting I & II

TASK / COMPETENCY
1.1 Demonstrate the use of drafting equipment and supplies.

PERFORMANCE OBJECTIVE
P1.1 Given a drafting station, drafting tools, and drafting materials, demonstrate the use of drafting equipment and supplies. Demonstration should include use of various scales, leads, erasers, and inking pens, and the measurement of angles using vernier scales on drafting machines.

PERFORMANCE MEASURE
M1.1 Demonstration, rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Use and maintain drafting machines and tools.
2. Use drafter's, architect's, engineer's, and metric scales.
3. Select appropriate leads and erasers for drawing.
4. Select, use, and maintain inking pens.
5. Identify standard sizes and types of drafting media.
6. Measure angles using vernier scales on drafting machines.
7. Make adjustments to drafting machine to install and align scales.

DUTY AREA
1. DEVELOPING BASIC LAB SKILLS

COURSE
Drafting I & II

TASK / COMPETENCY
1.2 Reproduce drawing.

PERFORMANCE OBJECTIVE
P1.2 Given an original drawing, various kinds of reproduction paper, and a blueline print machine, reproduce drawing. The most appropriate type of reproduction paper must be selected, and the print machine operated correctly.

PERFORMANCE MEASURE
M1.2 Demonstration, rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify and describe the different reproduction processes.
2. Describe the different types of reproduction paper and select the most appropriate one for the assigned print.
3. Operate a given print machine.
4. Prepare prints of original drawings.
5. Maintain the reproduction machine.

DUTY AREA
1. DEVELOPING BASIC LAB SKILLS

COURSE
Drafting I

TASK / COMPETENCY
1.3 Perform freehand lettering.

PERFORMANCE OBJECTIVE
P1.3 Given necessary drafting tools and materials, perform freehand lettering by selecting and sharpening pencil leads, constructing guide lines, and demonstrating lettering in vertical and inclined styles, both upper and lower case.

PERFORMANCE MEASURE
M1.3 Demonstration, in conformity with ANSI standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Select and sharpen pencil leads for lettering.
2. Select and sharpen pencil leads for the construction of guide lines.
3. Construct guide lines.
4. Construct freehand vertical and inclined letters.
5. Space letters and words properly, using predetermined guidelines.
6. Use and maintain mechanical lettering devices.

DUTY AREA
1. DEVELOPING BASIC LAB SKILLS

COURSE
Drafting I

TASK / COMPETENCY
1.4 Demonstrate line drawing technique.

PERFORMANCE OBJECTIVE
P1.4 Given a drafting station and standard drafting equipment, demonstrate line drawing technique by constructing lines, arcs, and circles. Demonstration should include selecting and sharpening appropriate pencil leads and utilizing acceptable line weights.

PERFORMANCE MEASURE
M1.4 Demonstration, in accordance with instructor-provided guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Select and sharpen pencil leads for line drawing.
2. Construct straight lines, circles, and arcs.
3. Demonstrate use of acceptable line weights.

DUTY AREA 2. CONSTRUCTING GEOMETRIC FIGURES

2.1 Draw straight lines.
2.2 Construct angles.
2.3 Construct plane figures.
2.4 Construct circles and arcs.
2.5 Construct irregular figures.

DUTY AREA
2. CONSTRUCTING GEOMETRIC FIGURES

COURSE
Drafting I

TASK / COMPETENCY
2.1 Draw straight lines.

PERFORMANCE OBJECTIVE
P2.1 Given standard drafting equipment and various geometric exercises, draw straight lines. Demonstration should include bisecting a line, dividing an angle, dividing a line into equal parts, and drawing parallel and perpendicular lines.

PERFORMANCE MEASURE
M2.1 Demonstration, rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Bisect a line and arc, and check accuracy with a drafting machine.
2. Divide an angle into two equal angles, using a compass.
3. Draw a line that is parallel to a given line, through a given point, and at a given distance from the original line.
4. Draw a line and divide it into a specified number of equal parts.
5. Draw a line perpendicular to a given line from a point.
6. Draw a line perpendicular through a point or a line.

DUTY AREA
2. CONSTRUCTING GEOMETRIC FIGURES

COURSE
Drafting I

TASK / COMPETENCY
2.2 Construct angles.

PERFORMANCE OBJECTIVE
P2.2 Given standard drafting equipment and various exercises and drawings, construct angles using geometric construction principles. Demonstration should include construction of a triangle with sides given, right angles, and an equilateral triangle with one side given.

PERFORMANCE MEASURE
M2.2 Demonstration, rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Construct triangle with sides given.
2. Construct right angles.
3. Construct an equilateral triangle with one side given.

DUTY AREA
2. CONSTRUCTING GEOMETRIC FIGURES

COURSE
Drafting I

TASK / COMPETENCY
2.3 Construct plane figures.

PERFORMANCE OBJECTIVE
P2.3 Given standard drafting equipment and various exercises and drawings, construct plane figures using geometric construction principles. Demonstration should include construction of squares, rectangles, and circles with inscribed hexagons and pentagons.

PERFORMANCE MEASURE
M2.3 Demonstration, rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Construct a square using established guidelines.
2. Construct a rectangle using established guidelines.
3. Construct a circle and inscribe a hexagon using specified guidelines.
4. Construct a hexagon with distance across flat sides given using specified guidelines.
5. Construct a pentagon by inscribing in a circle using specified guidelines.

DUTY AREA
2. CONSTRUCTING GEOMETRIC FIGURES

COURSE
Drafting I

TASK / COMPETENCY
2.4 Construct circles and arcs.

PERFORMANCE OBJECTIVE
P2.4 Given standard drafting equipment and various geometric exercises and drawings, construct circles and arcs using geometric construction principles. Demonstration should include construction of a circle through three given points and an arc tangent to specified angles.

PERFORMANCE MEASURE
M2.4 Demonstration, in accordance with instructor-provided guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Construct a circle through three given points using specified guidelines.
2. Construct an arc tangent to specified angles.

DUTY AREA
2. CONSTRUCTING GEOMETRIC FIGURES

COURSE
Drafting I

TASK / COMPETENCY
2.5 Construct irregular figures.

PERFORMANCE OBJECTIVE
P2.5 Given standard drafting equipment and various exercises and drawings, construct irregular figures using geometric construction principles. Demonstration should include a reverse curve tangent to and connecting to two nonparallel lines, an ellipse using the approximate ellipse with compass method, a parabola, and a parabolic curve joining two points.

PERFORMANCE MEASURE
M2.5 Demonstration, in accordance with instructor-provided guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Draw a reverse curve that is tangent to and connecting two nonparallel lines; mark the tangent points.
2. Draw an ellipse using the approximate ellipse with compass method.
3. Draw a parabola using specified guidelines.
4. Draw a parabolic curve joining two points using specified guidelines.

DUTY AREA 3. DRAWING ORTHOGRAPHIC PROJECTIONS

3.1 Sketch orthographic views.
3.2 Draw multiview projections.
3.3 Draw auxiliary views.

DUTY AREA
3. DRAWING ORTHOGRAPHIC PROJECTIONS

COURSE
Drafting I, DRF 121

TASK / COMPETENCY
3.1 Sketch orthographic views.

PERFORMANCE OBJECTIVE
P3.1 Given mechanical parts, pictorial drawings, or sketches, sketch orthographic views. The demonstration must include a two-view sketch and a three-view sketch.

PERFORMANCE MEASURE
M3.1 Demonstration, in accordance with ANSI standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Make a two-view sketch.
2. Make a three-view sketch.

DUTY AREA
3. DRAWING ORTHOGRAPHIC PROJECTIONS

COURSE
Drafting I

TASK / COMPETENCY
3.2 Draw multiview projections.

PERFORMANCE OBJECTIVE
P3.2 Given pictorial views, mechanical parts, or sketches, draw multiview projections. The projections must include top, front, and right side views, missing visible and hidden lines, circles and arcs drawn from a template, fillets, rounds, and runouts.

PERFORMANCE MEASURE
M3.2 Demonstration, in accordance with ANSI standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify types of planes and projection lines in orthographic views.
2. Construct top, front, and right side views.
3. Construct missing visible and hidden lines.
4. Construct circles and arcs using a template.
5. Construct one-, two-, and three-view drawings.
6. Construct fillets, rounds, and runouts.

DUTY AREA
3. DRAWING ORTHOGRAPHIC PROJECTIONS

COURSE
Drafting I, DRF 121

TASK / COMPETENCY
3.3 Draw auxiliary views.

PERFORMANCE OBJECTIVE
P3.3 Given mechanical parts, sketches, or multiview or pictorial drawings, draw auxiliary views. The auxiliary views should include primary and secondary auxiliary views of an inclined plane or other object, true-sized auxiliary views of a curved surface and of an oblique plane, a true length of an oblique surface, and the point of view of a line.

PERFORMANCE MEASURE
M3.3 Demonstration, in accordance with instructor-provided guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Construct a primary auxiliary view of an inclined plane.
2. Construct a true-size auxiliary view of a curved surface.
3. Construct a true length of an oblique surface.
4. Determine the true angle and slope of a line.
5. Determine the true angle between two planes.
6. Construct a secondary auxiliary view of an object.
7. Construct the point view of a line.
8. Construct the true-size auxiliary view of an oblique plane.

DUTY AREA 4. DRAWING SECTIONS

4.1 Draw standard sections.
4.2 Draw special sections.

DUTY AREA
4. DRAWING SECTIONS

COURSE
Drafting I, DRF 121

TASK / COMPETENCY
4.1 Draw standard sections.

PERFORMANCE OBJECTIVE
P4.1 Given mechanical parts, sketches, or multiview or pictorial drawings, draw standard sections by preparing and dimensioning a drawing with section and convention views. The drawings should include a full section, a half section, and an offset section of an object.

PERFORMANCE MEASURE
M4.1 Demonstration, in accordance with ANSI standards.

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Construct a full section of an object.
2. Construct a half section of an object.
3. Construct an offset section of an object.

DUTY AREA
4. DRAWING SECTIONS

COURSE
Drafting I, DRF 121

TASK / COMPETENCY
4.2 Draw special sections.

PERFORMANCE OBJECTIVE
P4.2 Given mechanical parts, sketches, or multiview or pictorial drawings, draw special sections by preparing and dimensioning a drawing with section and convention views. The drawing should show a broken-out section, a removed section, a revolved section, a rib section, an aligned section, an assembly section, adjacent parts in an assembly section, and conventional breaks.

PERFORMANCE MEASURE
M4.2 Demonstration, in accordance with ANSI standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Construct a broken-out section of an object.
2. Construct a removed section of an object.
3. Construct a revolved section of an object.
4. Construct a rib section of an object.
5. Construct an aligned section of an object with holes, ribs, or spokes.
6. Construct adjacent parts in an assembly section.
7. Construct an assembly section.
8. Construct conventional breaks.

DUTY AREA 5. DRAWING PICTORIALS

5.1 Draw axonometric projections.
5.2 Create oblique drawings.
5.3 Draw presentation drawings.
5.4 Draw exploded isometric assemblies.

DUTY AREA
5. DRAWING PICTORIALS

COURSE
Drafting I, DRF 121

TASK / COMPETENCY
5.1 Draw axonometric projections

PERFORMANCE OBJECTIVE
P5.1 Given a mechanical part or assembly, a sketch, or a multiview drawing, draw axonometric projections. The drawings should include isometric views of an object with rectangular features and of objects containing circular features on horizontal and vertical planes.

PERFORMANCE MEASURE
M5.1 Demonstration, in accordance with ANSI standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate how to draw the isometric axis.
2. Using isometric sketch paper, draw and dimension isometric views of
   a. an object with rectangular features, using the box method
   b. circular features on horizontal and vertical planes
   c. objects containing rectangular features, circles, arcs, and angles
   d. an object in full section
   e. an object in half section
   f. an object with irregular curves.
3. Draw and render in pencil an isometric view of an object.
4. Draw an isometric view of a mechanical assembly.
5. Draw and dimension an exploded isometric assembly.

DUTY AREA
5.2 DRAWING PICTORIALS

COURSE
Drafting I, DRF 121

TASK / COMPETENCY
5.2 Create oblique drawings.

PERFORMANCE OBJECTIVE
P5.2 Given a mechanical part or assembly, a sketch, or a multiview drawing, create oblique drawings. The drawings should show objects with rectangular and circular features on a single frontal plane and on planes other than frontal. The views should include cavalier, general, and cabinet oblique views.

PERFORMANCE MEASURE
M5.2 Demonstration, in accordance with ANSI standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate how to draw an oblique drawing to include angle of depth axis, scale of depth axis, and choice of position.
2. Sketch oblique views of
   a. a simple mechanical part with rectangular features, using the box method
   b. objects containing circular features on a single frontal plane
   c. objects having angles on planes other than the frontal plane.
3. Draw and dimension cavalier, general, and cabinet oblique views of objects with rectangular features.
4. Draw and dimension general and cabinet oblique views of objects containing circles, arcs, and angles.
5. Draw and dimension a general oblique view of an object in full section.
6. Draw and dimension a cabinet oblique view of an object in half section.
7. Draw and render in pencil an oblique view of an object in full section.
8. Draw an oblique view of a mechanical assembly.

DUTY AREA
5. DRAWING PICTORIALS

COURSE
Drafting I

TASK / COMPETENCY
5.3 Draw presentation drawings.

PERFORMANCE OBJECTIVE
P5.3 Given a mechanical part or assembly, a sketch, or a multiview drawing, draw presentation drawings. The drawings should show isometric views of the part or assembly, including one- and two-point perspectives and curves in perspective. The demonstration should include conceptual presentation sketches, design sketches, and diametric presentation drawings.

PERFORMANCE MEASURE
M5.3 Demonstration, in accordance with ANSI standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Sketch a one-point perspective.
2. Sketch a two-point perspective.
3. Construct a one-point perspective.
4. Construct a two-point perspective.
5. Construct curves in perspective.
6. Construct conceptual presentation sketches.
7. Construct design sketches.
8. Construct a diametric presentation drawing.

DUTY AREA
5. DRAWING PICTORIALS

COURSE
Drafting II

TASK / COMPETENCY
5.4 Draw exploded isometric assemblies.

PERFORMANCE OBJECTIVE
P5.4 Given a mechanical part or assembly, a sketch, or a multiview drawing, draw and dimension exploded isometric assemblies. The demonstration should include construction of an exploded assembly presentation drawing and labeling of an exploded view.

PERFORMANCE MEASURE
M5.4 Demonstration, in accordance with ANSI standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Construct an exploded assembly presentation drawing.
2. Label an exploded view.

DUTY AREA 6. USING DIMENSIONING TECHNIQUES

6.1 Demonstrate dimensioning techniques.
6.2 Interpret and apply tolerances.
6.3 Apply geometric tolerances.

DUTY AREA
6. USING DIMENSIONING TECHNIQUES

COURSE
Drafting II, DRF 121

TASK / COMPETENCY
6.1 Demonstrate dimensioning techniques.

PERFORMANCE OBJECTIVE
P6.1 Given necessary instruments, materials, and supplies, demonstrate dimensioning techniques. The drawings should include dimensioning of arcs, angles, curves, round-end shapes, spherical objects, cylindrical objects, tapers, a theoretical point of intersection, and an object using the aligned and unidirectional dimensioning system.

PERFORMANCE MEASURE
M6.1 Demonstration, in accordance with ANSI standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Construct arrowheads.
2. Dimension arcs.
3. Dimension angles.
4. Dimension curves.
5. Dimension rounded-end shapes.
6. Dimension spherical objects.
7. Dimension cylindrical objects.
8. Dimension tapers.
9. Dimension a theoretical point of intersection.
10. Dimension an object using the aligned and unidirectional dimensioning system.
11. Apply symbols for surface roughness control.
12. Add notes to drawings.

DUTY AREA
6. USING DIMENSIONING TECHNIQUES

COURSE
Drafting II, DRF 152

TASK / COMPETENCY
6.2 Interpret and apply tolerances.

PERFORMANCE OBJECTIVE
P6.2 Given a functional mechanical drawing, interpret and apply tolerances. Clearance and interference fit tolerances of mating parts must be calculated and dimensioned, and tolerances must be calculated and assigned using standard tables.

PERFORMANCE MEASURE
M6.2 Demonstration, in accordance with ANSI standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Interpret decimal tolerance dimensions.
2. Calculate and dimension clearance fit tolerances of mating parts.
3. Calculate and dimension interference fit tolerances of mating parts.
4. Calculate and assign tolerances to mating parts using standard fit tables.
5. Read appropriate technical material.
6. Apply ANSI Y 14.5 and ISO tolerances.

DUTY AREA
6. USING DIMENSIONING TECHNIQUES

COURSE
DRF 127

TASK / COMPETENCY
6.3 Apply geometric tolerances.

PERFORMANCE OBJECTIVE
P6.3 Given a functional mechanical drawing, apply geometric tolerances. Positional and form tolerancing symbols as well as symbols for true position must be applied.

PERFORMANCE MEASURE
M6.3 Demonstration, in accordance with ANSI standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Apply positional and form tolerancing symbols.
2. Apply symbols for true position.

DUTY AREA 7. DEMONSTRATING BASIC COMPUTER-AIDED DESIGN SKILLS

7.1 Demonstrate basic computer skills
7.2 Set drawing parameters.
7.3 Create drawing entities.
7.4 Edit drawing entities.
7.5 Control viewing.
7.6 Use drawing aids.
7.7 Save drawing files.
7.8 Control layers and linetypes.

DUTY AREA
7. DEMONSTRATING BASIC COMPUTER-AIDED DESIGN SKILLS

COURSE
Drafting I & II, DRF 201

TASK / COMPETENCY
7.1 Demonstrate basic computer skills.

PERFORMANCE OBJECTIVE
P7.1 Given a computer with a CAD program, demonstrate basic computer skills associated with computer aided drafting. Demonstration should include starting and exiting the program; formatting floppy disks; changing and creating directories; copying, deleting, and renaming files; and setting up a filing system.

PERFORMANCE MEASURE
M7.1 Demonstration, in accordance with instructor-provided guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Start up and shut down CAD program.
2. Format floppy disk.
3. Copy, delete, and rename files.
4. Create and change directories.
5. Set up and manage part number/filing system.

DUTY AREA
7. DEMONSTRATING BASIC COMPUTER-AIDED DESIGN SKILLS

COURSE
Drafting I & II, DRF 201

TASK / COMPETENCY
7.2 Set drawing parameters.

PERFORMANCE OBJECTIVE
P7.2 Given a computer with a CAD program, set drawing parameters. Demonstration must establish parameters necessary for the setup of a CAD drawing, including sheet size and drawing scale.

PERFORMANCE MEASURE
M7.2 Demonstration, in accordance with instructor-provided guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Create a new drawing.
2. Set drawing scale.
3. Set drawing sheet size.

DUTY AREA
7. DEMONSTRATING BASIC COMPUTER-AIDED DESIGN SKILLS

COURSE
Drafting I & II, DRF 201

TASK / COMPETENCY
7.3 Create drawing entities.

PERFORMANCE OBJECTIVE
P7.3 Given a computer with a CAD program, reference material, and hands-on practice, create drawing entities. The demonstration must include operating input device, controlling coordinates, controlling display scale, constructing lines, and creating text.

PERFORMANCE MEASURE
M7.3 Demonstration, rated acceptable according to instructor-specified guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Operate input device.
2. Demonstrate knowledge of draw commands.
3. Control coordinates.
4. Control display scale.
5. Construct lines.
6. Create text.

DUTY AREA
7. DEMONSTRATING BASIC COMPUTER-AIDED DESIGN SKILLS

COURSE
Drafting I & II, DRF 201

TASK / COMPETENCY
7.4 Edit drawing entities.

PERFORMANCE OBJECTIVE
P7.4 Given a computer with a CAD program, reference material, and hands-on practice, edit drawing entities. Demonstration should include erasing, moving, and modifying lines/text and cleaning up the drawing.

PERFORMANCE MEASURE
M7.4 Demonstration, in accordance with instructor-provided guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Apply knowledge of editing commands.
2. Erase lines/text.
3. Move lines/text.
4. Modify lines/text.
5. Clean up drawing.

DUTY AREA
7. DEMONSTRATING BASIC COMPUTER-AIDED DESIGN SKILLS

COURSE
Drafting I & II, DRF 201

TASK / COMPETENCY
7.5 Control viewing.

PERFORMANCE OBJECTIVE
P7.5 Given a computer with a CAD program, reference material, and hands-on practice, control viewing. Demonstration should include controlling display scale and line/text colors.

PERFORMANCE MEASURE
M7.5 Demonstration, in accordance with instructor-provided guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Apply knowledge of viewing commands.
2. Control display scale (e.g., zoom).
3. Control line/text colors.

DUTY AREA
7. DEMONSTRATING BASIC COMPUTER-AIDED DESIGN SKILLS

COURSE
Drafting I & II, DRF 201

TASK / COMPETENCY
7.6 Use drawing aids.

PERFORMANCE OBJECTIVE
P7.6 Given a computer with a CAD program, reference material, and hands-on practice, use drawing aid. Demonstration should include controlling line/text snap modes and identifying line/text values.

PERFORMANCE MEASURE
M7.6 Demonstration, in accordance with instructor-provided guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Apply knowledge of drawing aid commands.
2. Control line/text snap modes (e.g., grid).
3. Identify line/text values (e.g., list).

DUTY AREA
7. DEMONSTRATING BASIC COMPUTER-AIDED DESIGN SKILLS

COURSE
Drafting I & II, DRF 201

TASK / COMPETENCY
7.7 Save drawing files.

PERFORMANCE OBJECTIVE
P7.7 Given a computer with a CAD program, reference materials, and hands-on practice, save drawing files. Demonstration should include saving drawings to storage devices, retrieving stored drawings, and plotting drawings on media.

PERFORMANCE MEASURE
M7.7 Demonstration, in accordance with instructor-provided guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Apply knowledge of utilities commands.
2. Save drawings to storage devices.
3. Retrieve saved drawings from storage.
4. Plot drawings on media.

DUTY AREA
7. DEMONSTRATING BASIC COMPUTER-AIDED DESIGN SKILLS

COURSE
Drafting I & II, DRF 201

TASK / COMPETENCY
7.8 Control layers and linetypes.

PERFORMANCE OBJECTIVE
P7.8 Given a computer with a CAD program, reference materials, and hands-on practice, control layers and linetypes. Demonstration must include creating layers and linetypes, modifying layers, and changing line entities.

PERFORMANCE MEASURE
M7.8 Demonstration, in accordance with instructor-provided guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Create layers and linetypes.
2. Modify layers and change line entities.

DUTY AREA 8. CONSTRUCTING MACHINE DRAWINGS

8.1 Draw working drawings.
8.2 Draw fasteners.

DUTY AREA
8. CONSTRUCTING MACHINE DRAWINGS

COURSE
Drafting II, DRF 152

TASK / COMPETENCY
8.1 Draw working drawings.

PERFORMANCE OBJECTIVE
P8.1 Given the specifications, layout, sketches, actual parts or assembly, draw working drawings. The complete set of working drawings must include a set of detail drawings with appropriate dimensions and tolerances, an assembly drawing, a detailed block and revision block, a parts list, and determination of ranges of motion.

PERFORMANCE MEASURE
M8.1 Student-produced working drawings; all components meet standards of the profession

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Draw a set of detail drawings with appropriate dimensions and tolerances using English or metric measure.
2. Draw an assembly drawing.
3. Complete a detailed block and revision block.
4. Complete a parts list.
5. Make a drawing revision if appropriate.
6. Determine ranges of motion of moving parts to ensure clearances.
7. Create and document bill of materials.

DUTY AREA
8. CONSTRUCTING MACHINE DRAWINGS

COURSE
Drafting II, DRF 152

TASK / COMPETENCY
8.2 Draw fasteners.

PERFORMANCE OBJECTIVE
P8.2 Given required materials, standards, and machine parts, draw fasteners. The drawings must include detail representations of threads (with simplified and schematic symbols for internal and external threads), of finished and unfinished nuts and bolts, and of rivets, keys, and taper pins.

PERFORMANCE MEASURE
M8.2 Student-produced drawings; all components meet standards of the profession

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Use thread and fastener tables.
2. Draw a detail representation of threads (unified thread, acme thread, and square thread).
3. Draw a detail representation of finished and unfinished bolts and nuts.
4. Draw a detailed representation of rivets, keys, and taper pins.
5. Draw simplified and schematic symbols for internal and external threads.
6. Select fasteners appropriate for the required tolerances, strengths, and sizes of assemblies.

DUTY AREA 9. PREPARING ARCHITECTURAL PLANS

9.1 Draw and dimension a floor plan.
9.2 Draw a foundation plan.
9.3 Draw exterior elevation plans.
9.4 Draw door and window schedules.
9.5 Draw sections.
9.6 Draw an electrical plan.
9.7 Draw a plumbing plan.
9.8 Create a presentation design.

DUTY AREA
9. PREPARING ARCHITECTURAL PLANS

COURSE
Drafting II, ARC 251

TASK / COMPETENCY
9.1 Draw and dimension a floor plan.

PERFORMANCE OBJECTIVE
P9.1 Given architectural design data, preliminary plan layouts, and necessary equipment and materials, draw and dimension a floor plan. Drawing should include architectural symbols and types of information commonly shown on a floor plan, correct dimensioning, and general and specific notes.

PERFORMANCE MEASURE
M9.1 Student-produced drawings, in accordance with instructor-provided guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Sketch a preliminary plan layout.
2. Identify types of information commonly shown on floor plans.
3. Identify architectural symbols commonly used on a floor plan.
4. Dimension floor plan.
5. Use architectural templates.
6. List steps required to draw a floor plan.
7. Develop general and specific notes that appear on a floor plan.

DUTY AREA
9.2 PREPARING ARCHITECTURAL PLANS

COURSE
Drafting II, ARC 251

TASK / COMPETENCY
9.2 Draw a foundation plan.

PERFORMANCE OBJECTIVE
P9.2 Given architectural design data, a floor plan, necessary sketches, equipment, and materials, draw a foundation plan. Plan should contain foundation details using basement or slab construction, correct dimensioning, and correctly calculated footing and wall sizes for the given data.

PERFORMANCE MEASURE
M9.2 Student-produced drawing; all components meet standards of the profession

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. List the steps required to draw a foundation plan.
2. Discuss design considerations for a crawl space.
3. Dimension a foundation plan.
4. Use design data to determine foundation wall size.
5. Calculate footing size.
6. Detail foundation using basement construction.
7. Detail foundation using slab construction.

DUTY AREA
9. PREPARING ARCHITECTURAL PLANS

COURSE
Drafting II, ARC 251

TASK / COMPETENCY
9.3 Draw exterior elevation plans.

PERFORMANCE OBJECTIVE
P9.3 Given a site plan, a floor plan, specifications, a foundation plan, exterior design information, a wall section, a sketch of preliminary elevations, and necessary materials and equipment, draw exterior elevation plans. Drawing must include all details from the sketch and floor plan, all thru-wall features, and roof elevation details, and must accurately reflect the data provided.

PERFORMANCE MEASURE
M9.3 Student-provided drawings, all items rated acceptable based on instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Sketch preliminary elevations.
2. Lay out details from the sketch and floor plan.
3. Draw thru-wall features (window, doors, etc.).
4. Draw roof elevation details.

DUTY AREA
9. PREPARING ARCHITECTURAL PLANS

COURSE
Drafting II, ARC 251

TASK / COMPETENCY
9.4 Draw door and window schedules.

PERFORMANCE OBJECTIVE
P9.4 Given specific requirements pertaining to doors and windows and the necessary materials and equipment, draw door and window schedule. Schedules must appear on the same page(s), in parallel columns, and accurately reflect the requirements provided.

PERFORMANCE MEASURE
M9.4 Student-provided drawings; all components meet standards of the profession

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Prepare a minimum layout for window and door schedules.
2. Indicate reference marks for doors and windows.
3. Describe information in the window and door schedules.
4. Place a window and door schedule on a set of drawings.

DUTY AREA
9. PREPARING ARCHITECTURAL PLANS

COURSE
Drafting II, ARC 251

TASK / COMPETENCY
9.5 Draw wall sections.

PERFORMANCE OBJECTIVE
P9.5 Given a typical plan, specifications, and necessary materials and equipment, draw wall sections. Drawing should include section details for brick veneer, frame, and masonry wall construction, typical cornice details, standard symbols for construction materials, door and window sections, and typical notes and dimensions.

PERFORMANCE MEASURE
M9.5 Student-produced drawings, all items rated acceptable based on instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain the purpose of a wall section.
2. Discuss the purpose of a structural section.
3. Draw section details for a frame wall construction, a brick veneer on a frame wall construction, and a masonry wall construction.
4. Demonstrate the procedure for laying out a typical wall section.
5. Illustrate typical cornice details.
6. Identify standard architectural symbols for selected construction materials.
7. Develop notes and dimensions that appear on a typical wall plan.
8. Demonstrate the procedure for preparing a structural section.
9. Apply typical reference symbols to section details.
10. Draw door and window sections.

DUTY AREA
9. PREPARING ARCHITECTURAL PLANS

COURSE
Drafting II, ARC 251

TASK / COMPETENCY
9.6 Draw an electrical plan.

PERFORMANCE OBJECTIVE
P9.6 Given reference materials and the necessary supplies and equipment, draw an electrical plan. Plan should use standard electrical symbols and show location of all electrical components.

PERFORMANCE MEASURE
M9.6 Student-produced drawings, all components conform to AIA electrical plan requirements for residential construction

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain the difference between 110 and 220 volts as applicable to different appliances.
2. Explain the different electrical symbols used on a drawing.
3. Locate electrical outlets, switches, and fixtures on plan.
4. Draw electrical plan.

DUTY AREA
9. PREPARING ARCHITECTURAL PLANS

COURSE
Drafting II, ARC 251

TASK / COMPETENCY
9.7 Draw a plumbing plan.

PERFORMANCE OBJECTIVE
P9.7 Given reference materials, client requirements, and the necessary equipment and materials, draw a plumbing plan. Plan should use standard plumbing symbols and show location of all plumbing components, according to existing codes.

PERFORMANCE MEASURE
M9.7 Student-produced drawings; all components conform to applicable codes and meet standards of the profession

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Interpret blueprints.
2. Locate and use plumbing codes.
3. Locate and use plumbing symbols.
4. Designate plumbing component locations.
5. Locate and use technical literature.
6. Calculate material lengths.
7. List plumbing symbols contained in ANSI Standard Y 32.4.

DUTY AREA
9. PREPARING ARCHITECTURAL PLANS

COURSE
Drafting II, ARC 251

TASK / COMPETENCY
9.8 Create a presentation design.

PERFORMANCE OBJECTIVE
P9.8 Given a preliminary presentation layout and necessary materials and equipment, create a presentation design. Drawings should include techniques of rendering to show texture of surfaces and materials, foliage, shadows, and shading, and design must be matted.

PERFORMANCE MEASURE
M9.8 Student-produced presentation design; all components reflect the preliminary layout and meet standards of the profession

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain the advantages and disadvantages of pencil rendering.
2. Demonstrate how to indicate the texture of surfaces and materials.
3. Demonstrate various ways of showing foliage, using different techniques.
4. Find the shadow of any line on a perspective.
5. Add shadows to a perspective.
6. Use shading in rendering.
7. Demonstrate the techniques of rendering to represent the texture of building materials.
8. Discuss how balance relates to a rendering.
9. Demonstrate the procedure for matting a rendering.
10. Demonstrate the use of various media on mat boards.
11. Use a scratchboard.

DUTY AREA 10. DEMONSTRATING CIVIL AND SURVEY DRAFTING TECHNIQUES

10.1 Demonstrate the use of a transit.
10.2 Generate civil and survey drawings.

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DUTY AREA
10. DEMONSTRATING CIVIL AND SURVEY DRAFTING TECHNIQUES

COURSE
Drafting II

TASK / COMPETENCY
10.1 Demonstrate the use of a transit.

PERFORMANCE OBJECTIVE
P10.1 Given tripod, transit, and instructor-provided instruction, demonstrate the use of a transit. Demonstration should include setting up and leveling transit, focusing crosshairs, running levels, and recording field notes.

PERFORMANCE MEASURE
M10.1 Demonstration, in accordance with instructor-provided guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Set up tripod.
2. Set up and level transit.
3. Focus crosshairs.
4. Run levels and record notes.
5. Record field notes.

DUTY AREA
10. DEMONSTRATING CIVIL AND SURVEY DRAFTING TECHNIQUES

COURSE
Drafting II

TASK / COMPETENCY
10.2 Generate civil and survey drawings.

PERFORMANCE OBJECTIVE
P10.2 Given data, information, and simple drawings, generate civil and survey drawings. Demonstration should include converting azimuths to bearings, plotting points by coordinate method, and drawing traverses, contours, and profiles.

PERFORMANCE MEASURE
M10.2 Demonstration, in accordance with instructor-provided guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify common types of maps.
2. Identify topographical features and areas.
3. Convert azimuths to bearings.
4. Plot points by coordinate method.
5. Draw traverses, contours, and profiles.

DUTY AREA 11. CONSTRUCTING ELECTRICAL AND ELECTRONICS DRAWINGS

11.1 Identify electronic symbols.
11.2 Construct schematic diagrams.

DUTY AREA
11. CONSTRUCTING ELECTRICAL AND ELECTRONICS DRAWINGS

COURSE
DRF 211

TASK / COMPETENCY
11.1 Identify electronic symbols.

PERFORMANCE OBJECTIVE
P11.1 Given an electrical or electronics diagram, identify electronic symbols. Demonstration must include recognition of graphic symbols and selection of appropriate symbols to represent the parts of the circuit.

PERFORMANCE MEASURE
M11.1 Demonstration, in accordance with instructor-provided guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain electrical and electronic diagrams.
2. Recognize graphic symbols used in electrical and electronic diagrams.
3. Select appropriate symbols for specific parts of the circuit.

DUTY AREA
11. CONSTRUCTING ELECTRICAL AND ELECTRONICS DRAWINGS

COURSE
DRF 211

TASK / COMPETENCY
11.2 Construct schematic diagrams.

PERFORMANCE OBJECTIVE
P11.2 Given an electrical component, construct schematic diagrams. Diagrams should show the connection and function of a circuit in its simplest form, using graphical symbols, and should utilize accepted symbols for electrical components, integrated circuits, transitions, and semiconductors. .

PERFORMANCE MEASURE
M11.2 Student-produced diagrams, all items rated acceptable based on instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Draw the function of a circuit in its simplest form, using graphical symbols.
2. Utilize accepted symbols for electrical components.
3. Utilize integrated circuit symbols.
5. Utilize transistor and semiconductor symbols.

DUTY AREA 12. CONSTRUCTING HYDRAULIC AND PNEUMATIC POWER DRAWINGS

12.1 Construct hydraulic diagrams.
12.2 Construct pneumatic diagrams.

DUTY AREA
12. CONSTRUCTING HYDRAULIC AND PNEUMATIC POWER DRAWINGS

COURSE
DRF 216

TASK / COMPETENCY
12.1 Construct hydraulic diagrams.

PERFORMANCE OBJECTIVE
P12.1 Given a design situation which requires the utilization of fluid power, construct hydraulic diagrams illustrating the laws of fluid flow. Diagrams should include a pictorial diagram of a hydraulic system, a graphical diagram of a hydraulic circuit, and appropriate graphic symbols for a hydraulic system.

PERFORMANCE MEASURE
M12.1 Student-produced diagrams, all items rated acceptable based on instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Make a pictorial diagram of a hydraulic system.
2. Make a graphical diagram of a hydraulic circuit.
3. Lay out hydraulic systems using graphic symbols.

DUTY AREA
12. CONSTRUCTING HYDRAULIC AND PNEUMATIC POWER DRAWINGS

COURSE
DRF 216

TASK / COMPETENCY
12.2 Construct pneumatic diagrams.

PERFORMANCE OBJECTIVE
P12.2 Given a design situation which requires the utilization of pneumatic power, construct pneumatic diagrams illustrating the laws of pneumatics. Diagrams should include a pictorial diagram of a pneumatic system, a graphical diagram of a pneumatic circuit, and appropriate graphic symbols for a pneumatic system.

PERFORMANCE MEASURE
M12.2 Student-produced diagrams, all items rated acceptable based on instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Make a pictorial diagram of a pneumatic system.
2. Make a graphical diagram of a pneumatic circuit.
3. Lay out pneumatic systems using graphic symbols.

DUTY AREA 13. CONSTRUCTING SPUR AND BEVEL GEAR DRAWINGS

13.1 Construct detail spur gear drawings.
13.2 Construct detail bevel gear drawings.

DUTY AREA
13. CONSTRUCTING SPUR AND BEVEL GEAR DRAWINGS

COURSE
DRF 211

TASK / COMPETENCY
13.1 Construct detail spur gear drawings.

PERFORMANCE OBJECTIVE
P13.1 Given a mechanical part which requires power transmission, construct detail spur gear drawings. Demonstration should include calculating gear ratios and speeds and determining gear rotation.

PERFORMANCE MEASURE
M13.1 Demonstration, in accordance with instructor-provided guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Calculate gear ratios.
2. Determine gear rotation.
3. Calculate gear speeds.
4. Construct spur gear drawings.

DUTY AREA
13. CONSTRUCTING SPUR AND BEVEL GEAR DRAWINGS

COURSE
DRF 211

TASK / COMPETENCY
13.2 Construct detail bevel gear drawings.

PERFORMANCE OBJECTIVE
P13.2 Given a mechanical part which requires power transmission, construct detail bevel gear drawings. Demonstration should include calculating gear ratios and speeds and determining gear rotation.

PERFORMANCE MEASURE
M13.2 Demonstration, in accordance with instructor-provided guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Calculate gear ratios.
2. Determine gear rotation.
3. Calculate gear speeds.
4. Explain the difference between spur and bevel gears.
5. Construct bevel gear drawings.

DUTY AREA 14. DESIGNING MECHANICAL PARTS PROJECT

14.1 Plan a mechanical design project.
14.2 Design a mechanical part or parts.

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DUTY AREA
14. DESIGNING MECHANICAL PARTS PROJECT

COURSE
DRF 298

TASK / COMPETENCY
14.1 Plan a mechanical design project.

PERFORMANCE OBJECTIVE
P14.1 Given a choice of design projects related to an occupational objective, plan a mechanical design project utilizing various design approaches. Demonstration should include sketching preliminary plans, performing supporting calculations, conducting team meetings, outlining steps in the project, and making a presentation.

PERFORMANCE MEASURE
M14.1 Role-play activity; student participation meets criteria specified in instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Choose a mechanical design project.
2. Sketch preliminary plans.
3. Perform supporting calculations.
4. Conduct team meetings.
5. Outline steps in the design project.
6. Make a presentation.

DUTY AREA
14. DESIGNING MECHANICAL PARTS PROJECT

COURSE
DRF 298

TASK / COMPETENCY
14.2 Design a mechanical part or parts.

PERFORMANCE OBJECTIVE
P14.2 Given design project related to an occupational objective, design a mechanical part or parts utilizing various design approaches. Demonstration should include preparing design layout, conducting team meeting, refining product, preparing detail drawings, constructing charts, illustrations, and graphs, writing reports, and making a presentation.

PERFORMANCE MEASURE
M14.2 Role-play activity; student participation meets criteria specified in instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Prepare design layout.
2. Conduct team meeting.
3. Do product refinement.
4. Prepare detail drawings.
5. Construct charts, illustrations, and graphs.
6. Participate in team activities.
7. Write technical and non-technical reports.
8. Make a presentation.

DUTY AREA 15. USING ADVANCED COMPUTER-AIDED DESIGN SKILLS

15.1 Develop three-dimensional drawings.
15.2 Develop solid model drawings.

DUTY AREA
15. USING ADVANCED COMPUTER-AIDED DESIGN SKILLS

COURSE
DRF 202

TASK / COMPETENCY
15.1 Develop three-dimensional drawings.

PERFORMANCE OBJECTIVE
P15.1 Given a mechanical part and a computer with CAD program, develop three-dimensional drawings using elevation and thickness to create extruded entities, standard drawing methods in different coordinate systems, three-dimensional polygon meshes, and three-dimensional objects.

PERFORMANCE MEASURE
M15.1 Demonstration, in accordance with instructor-provided guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Create three-dimensional display.
2. Create three-dimensional shapes.
3. Modify three-dimensional shapes.

DUTY AREA
15. USING ADVANCED COMPUTER-AIDED DESIGN SKILLS

COURSE
DRF 202

TASK / COMPETENCY
15.2 Develop solid model drawings.

PERFORMANCE OBJECTIVE
P15.2 Given a mechanical part and a computer with a CAD program, develop solid model drawings utilizing AME (Advanced Modeling Extension) software. Demonstration should include constructing and editing solid composite models and displaying solids with hidden lines removed and as shaded renderings.

PERFORMANCE MEASURE
M15.2 Demonstration, in accordance with instructor-provided guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Create solid shapes from two-dimensional objects.
2. Construct solid composite models.
3. Edit solid models.
4. Display solids with hidden lines removed and as shaded renderings.
5. Construct two-dimensional views from a solid model.

DUTY AREA 16. PREPARING FOR INSTRUCTIONAL ACTIVITIES

16.1 Participate in VICA activities.
16.2 Participate in lab safety activities.

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DUTY AREA
16. PREPARING FOR INSTRUCTIONAL ACTIVITIES

COURSE
Drafting I & II

TASK / COMPETENCY
16.1 Participate in VICA activities.

PERFORMANCE OBJECTIVE
P16.1 Given VICA, instructor's guidelines, and information on parliamentary procedure, participate in VICA activities. Demonstration should include selecting a committee to join, working on a VICA club project, or entering a VICA contest, after discussing the purposes and organization of the VICA in detail.

PERFORMANCE MEASURE
M16.1 Demonstration, in accordance with instructor-provided guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify advantages and responsibilities of VICA membership.
2. Recite the VICA motto and pledge.
3. Identify VICA colors and emblem symbols.
4. Identify competitive events for drafting/drawing sponsored by VICA for local, state, and national contests.
5. Identify VICA activities that benefit the community and the student.
6. Explain the VICA club structure.
7. Use parliamentary procedure.
8. Participate in an opening and closing ceremony.
9. View and discuss the filmstrip *VICA: Going All the Way* or the videotape *You're Number One with VICA*.

DUTY AREA
16. PREPARING FOR INSTRUCTIONAL ACTIVITIES

COURSE
All secondary and postsecondary

TASK / COMPETENCY
16.2 Participate in lab safety activities.

PERFORMANCE OBJECTIVE
P16.2 Given drafting lab safety rules and regulations, participate in lab safety activities. Demonstration must include a discussion of all safety rules and hazards, steps to follow in maintaining cleanliness and order, steps to follow in case of an accident, and fire exit procedures.

PERFORMANCE MEASURE
M16.2 Demonstration, in accordance with instructor-provided guidelines and OSHA specifications

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. List all safety rules of the drafting lab.
2. Identify all possible safety hazards.
3. List steps in maintaining a clean and orderly lab.
4. List steps to follow in case of an accident.
5. Identify possible fire hazards in the lab.
6. Explain fire exit procedures.
7. Recite the student safety pledge.

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**Note: Resources marked with an asterisk are cited as the primary resources used by project site.*

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Careers in Drafting. (two filmstrips with audio cassettes) Doubleday Multimedia, 1371 Reynolds Ave., Santa Ana, CA 95705.

Concepts and Principles of Functional Drafting. (20 min., b & w) TAD Products of the University of Minnesota, P.O. Box 1798, Costa Mesa, CA 92626.

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SLIDES

AIASA - A Classroom Experience. National AIASA, Reston, VA 22090.

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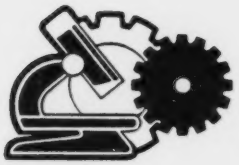
TASK ANALYSES

ENGINEERING, TRADE, AND TECHNICAL CLUSTER



Precision Machining Technology

A COMPETENCY-BASED CURRICULUM GUIDE

DEVELOPED BY

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Carroll County Public Schools
Grayson County Public Schools
Smyth County Public Schools
Wythe County Public Schools
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Wytheville Community College

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OCCUPATIONAL ANALYSIS

Occupational Task List: Precision Machining Technology

A. ORIENTING THE NEW EMPLOYEE
- Identify machine shop procedures and policies.
- Demonstrate shop safety and emergency procedures.
- Identify machine use and operation.
- Inspect the work area to ensure a safe working environment.
- Maintain inventory of supplies and materials needed for machine work.
- Demonstrate positive work attitudes.
- Demonstrate an acceptable work ethic.
- Determine the importance of advanced training.

B. PERFORMING MATHEMATICAL CALCULATIONS
- Calculate tolerances or allowances for proper fit.
- Calculate indexing a square, a hexagon, and a gear blank.
- Calculate machine speeds and feeds by formulas.
- Convert English measurements to metric.
- Determine clearance, relief, and rake of cutting tools.
- Use machining handbooks, charts, and tables to aid in mathematical calculations.
- Convert fractions of an inch to decimal equivalents and vice versa.

C. MEASURING AND PERFORMING LAYOUT
- Measure, using a machinist's combination set.
- Measure, using a machinist's rule.
- Measure, using a depth gauge and a micrometer depth gauge.
- Measure, using a vernier or dial caliper.
- Measure, using a dial indicator.
- Measure, using an inside micrometer.
- Measure, using an outside micrometer.
- Measure, using various gauges and templates.
- Determine the accuracy of precision measurement instruments, using gauge blocks and other master references.
- Measure, using a universal bevel protractor.
- Measure, using a sine bar.
- Perform layout for precision machine work, using layout instruments.
- Measure, using a height gauge.
- Measure, using a bore gauge.
- Measure, using coordinate measuring machine.
- Measure, using the optical comparator.

D. PRODUCING AND INTERPRETING DRAWINGS
- Interpret industrial drawings.
- Demonstrate the use of selected drafting and sketching equipment.
- Demonstrate line-sketching technique.
- Sketch straight lines.
- Construct angles.
- Construct plane figures.
- Construct circles and arcs.
- Sketch orthographic views.
- Sketch multiview projections.
- Sketch auxiliary views.

Sketch standard sections.
Sketch special sections.

E. PERFORMING BENCH WORK
Cut materials with a hand hacksaw.
Cut threads, using hand taps.
Cut threads, using dies.
Disassemble and assemble parts.
Hand-sharpen cutting tools, using abrasive stones.
Ream holes, using hand reamers.
Remove damaged screws and other non-hardened thread hardware.
Work and shape metal, using hand tools.
Clamp the work in a holding device.
Perform bench filing.

F. PROCESSING METALS
Identify ferrous and nonferrous metals.
Determine metal type by color code or spark test.
Use hardening processes.
Use softening processes.
Case-hardened metals.
Temper metals.
Anneal hardened metals.

G. OPERATING POWER SAWS
Select appropriate blades.
Select and set speeds and feeds for sawing operations.
Saw to scribed lines, using a metal band saw.
Measure and cut metal, using a power saw.
Remove and replace saw blades.
Cut and weld a band saw blade for contour sawing.

H. OPERATING DRILLING MACHINES
Identify the characteristics of the material to be drilled.
Determine holding techniques.
Select a tool or cutter for the drill press operation.
Secure the tool or cutter in the drill press spindle.
Select a sleeve to suit the drill.
Set the drill press feeds and speeds.
Drill a hole to size.
Sharpen the drill bit by hand and by using drill sharpener.
Use a tapping attachment to tap a hole.
Hand-tap a hole.

I. OPERATING ABRASIVE MACHINES
Install the grinding wheel.
Dress and true the grinding wheel.
Balance the grinding wheel.
Select appropriate attachments and grind workpiece to blueprint specifications.
Set up the grinder to run the workpiece on a magnetic chuck.
Perform surface-grinding operations.
Measure, inspect, and rework the workpiece on the grinding machine.
Shape chisel on the pedestal grinder.
Grind and sharpen a preshaped lathe tool.
Perform belt and disk grinding operations.
Perform honing operations.

J. OPERATING LATHES

Select and set speeds and feeds.
Set up tool holders, fixtures, and attachments.
Rough-cut and finish-cut, using a lathe.
Perform lathe filing.
Knurl parts, using a lathe.
Cut off the workpiece, using a lathe.
Align lathe centers, using precision measurement.
Drill holes, using a lathe.
Countersink holes, using a lathe.
Ream holes, using a lathe.
Tap threads, using a lathe.
Die-cut threads, using a lathe (hand-threading).
Cut short, externally tapered surfaces.
Perform contour, angular, or radial cuts, using a lathe.
Cut external threads, using a lathe.
Rechase threads, using a lathe.
Cut long, externally tapered surfaces, using a taper attachment.
Bore holes, using a lathe.
Counterbore holes, using a lathe.
Cut internal threads, using a lathe.
Cut internally tapered surfaces.
Die-cut threads with a lathe, using die heads.
Set up the tool post grinder.
Use the tool post grinder.

K. OPERATING MILLING MACHINES

Align the milling machine head and fixtures.
Mount and align milling machine attachments.
Select and set speeds and feeds for milling work.
Perform end milling.
Perform flycutting operations.
Drill holes, using a milling machine.
Mill an angle.
Mill arcs.
Perform reaming operations.
Cut external keyways.
Bore holes, using a milling machine.
Perform form milling.
Perform indexing operations.
Mill gears.
Perform straddle-milling operations on the horizontal mill.
Mill internal slots, using a slotting attachment.
Remove chips.

L. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

Develop programmed instructions from blueprint.
Develop programmed instructions from sample part.
Develop a production plan.
Choose machine tools for part.
Select tools and holders.
Select spindle speeds and feeds.
Position workpiece in relation to machine axis.
Determine absolute or incremental mode.
Compute polar/rectangular coordinates.
Verify cutter path.

Depict part graphically.
Program tool-change procedure.
Prepare operator instructions for piece part.
Select canned cycles.
Program restart points.
Enter tool offset.
Load tools in caddy.
Check tooling sheet.
Install cutting tools and holders.
Call up program in distributed numerical control.
Mount holder and tool on spindle manually.
Load automatic tool changer.
Mount workpiece.
Set zero.
Dry run program.
Edit program.
Alter speed/feed commands.
Key in program on machine.
Complete machine-tool safety setup.
Align holding device with machine axis.
Change tool holder (setup).
Modify data input program.
Set manual mode control.
Turn on power.
Interpret status lights.
Perform sequence search.
Initiate program restart from zero (absolute mode).
Check cutting fluids.
Check surface finish.
Index turret.
Differentiate among machine controls.
Change cutting tool.
Adjust tool offset manually.
Execute emergency stop.
Activate automatic cycle mode.
Interrupt automatic cycle mode manually.
Run segment of program.
Interpret operator-related screen messages.

M. WORKING WITH CAD-CAM SYSTEMS

Develop a model of a machining process.
Transfer a CNC program from computer to CNC machine, using a Distributive Numerical Control System.
Transfer a CAD file to a CAM system.

N. MAINTAINING MACHINES AND TOOLS

Inspect and change drive pulleys or belts.
Inspect and remove, replace, or adjust machine guards.
Replace and adjust machine parts.
Inspect and repair hand tools.
Perform preventive maintenance on lathes.
Perform preventive maintenance on milling machines.
Perform maintenance on drill presses.
Perform maintenance on grinders.
Perform maintenance on power saws.
Perform maintenance on arbor press.

Perform maintenance on hydraulic press.
Clean and lubricate a vise.
Install, inspect, level, and fasten down machines.
Clean and store hand tools, cutters, fixtures, jigs, and attachments.
Store grinding wheels.
Prepare and store precision tools.
Dispose of scrap metal, chips, shavings, trash, and waste materials.
Scrape and paint machines.

O. COMMUNICATING ON THE JOB
Develop effective listening skills.
Demonstrate various modes of on-the-job communication.
Demonstrate public speaking ability.
Lead an informal meeting.
Write a technical report.
Write a clear set of directions.

MACHINE TRADE OCCUPATIONS

The courses of study listed in the "Program Design" section on the following page lead to entry-level employment in the machine trades occupations listed below. Descriptions of each occupation are found in the *Dictionary of Occupational Titles.*

600.130-010	MACHINE-SHOP SUPERVISOR, TOOL (machine shop)
600.260-022	MACHINIST, EXPERIMENTAL (machine shop) alternate titles: prototype machinist
600.280-022	MACHINIST (machine shop) alternate titles: machinist, first-class; machinist, general
600-280-042	MAINTENANCE MACHINIST (machine shop) alternate titles: machine repairer; machinist, general maintenance; shop mechanic
600.281-014	LAY-OUT INSPECTOR (machine shop) alternate titles: inspector, rough castings; lay-out worker
600.281-018	LAY-OUT WORKER (machine shop)
600.380-018	MACHINE SET-UP OPERATOR (machine shop) alternate titles: machine operator, all around; machine operator, general; machine specialist; machinist
601.260-010	TOOL-AND-DIE MAKER (machine shop)
601.261-010	INSPECTOR, SET-UP AND LAY-OUT (machine shop)
601.280-042	TOOL MAKER (machine shop)
601.280-054	TOOL-MACHINE SET-UP OPERATOR (machine shop) alternate titles: machine-tool operator, general; machinist; set-up-operator, tool
601.281-022	INSPECTOR, TOOL (machine shop) alternate titles: precision inspector; surface-plate inspector; tool-and-die inspector; tool-and-gauge inspector; tooling inspector
601.281-026	TOOL-MAKER, BENCH (machine shop)
609.130-010	MACHINE-SHOP SUPERVISOR, PRODUCTION (machine shop)
609.131-010	INSPECTION SUPERVISOR (machine shop) alternate titles: inspector, chief; quality-control supervisor
609.262-010	TOOL PROGRAMMER, NUMERICAL, CONTROL (electron. comp.) alternate titles: programmer operator, numerical control; soft tooling technician
609.360-010	NUMERICAL CONTROL MACHINE SET-UP OPERATOR (machine shop)
609.362-010	NUMERICAL CONTROL MACHINE OPERATOR (machine shop)
609.684-010	INSPECTOR, GENERAL (any industry) alternate titles: bench inspector; parts inspector; gauger
638.261-030	MACHINE REPAIRER, MAINTENANCE (any industry)
638.281-014	MAINTENANCE MECHANIC (any industry) alternate titles: fixer; machine-maintenance servicer; machine overhauler; machine repairer; mechanical adjuster; repair mechanic; tool-and-machine maintainer

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PROGRAM DESIGN

Secondary Course Offerings

English 9-12
Applied Math I, or Algebra I
Applied Math II, or Geometry
Applied Math III, or Algebra II
Probability and Statistics or
Advanced Algebra and Trigonometry
Lab Sciences 9, 10
Principles of Technology, or Physics
World Studies
Virginia and U.S. History
Virginia and U.S. Government
Health and Physical Education 9, 10
Vocational Electives 9, 10
Precision Machining Technology I, II

Postsecondary Course Requirements

Practical Writing I: ENG 101
Introduction to Speech Communication: SPD 110
Basic Technical Mathematics I-II: MTH 103-104
Social/Behavioral Sciences (e.g., Human Relations: PSY 120) (2 courses)
Health or Physical Education (e.g., Personal Health and Fitness: HLT 160) (2 courses)
Orientation: STD 100
Engineering Graphics I: EGR III
Introduction to Problem Solving in Technology: EGR 105
Blueprint Reading II: DRF 162
Materials and Processes in Manufacturing I-II: IND 113-114
Machine Shop Practices: MAC 107
Computer Elective (e.g., Keyboarding, DOS, Windows, WordPerfect, Spread Sheet, Data Base, etc.)
Metals/Heat Treatment: MAC 146
Machine Tool Maintenance: MAC 151
Production Machining Techniques: MAC 206
Standards, Measurements, and Calculations: MAC 209
Numerical Control Programming: MAC 125
Machining Techniques: MAC 205
Technical Electives (e.g., Computer-Aided Manufacturing, Computer-Aided Drafting, Statistical Process, Control, Welding, etc.)
Advanced Numerical Control: MAC 245
Machine Shop Operations: MAC 106
Machine Shop Operations: MAC 225

DUTY AREA 1. ORIENTING THE STUDENT

1.1 Identify machine shop procedures and policies.
1.2 Demonstrate shop safety and emergency procedures.
1.3 Identify machine use and operation.
1.4 Inspect the work area to ensure a safe working environment.
1.5 Maintain inventory of supplies and materials needed for machine work.
1.6 Demonstrate positive work attitudes.
1.7 Demonstrate an acceptable work ethic.
1.8 Determine the importance of advanced training.

RELATED ACADEMIC STANDARDS OF LEARNING

(Based on 1995 SOLs)

ENGLISH		TECHNICAL COMPETENCY
10.1	The student will participate in and report small-group learning activities.	1.6-1.8
10.2	The student will critique oral reports of small-group learning activities.	1.6-1.8
10.4	The student will read and interpret printed consumer materials	1.8
10.9	The student will use writing to interpret, analyze, and evaluate ideas.	1.6-1.8
10.10	The student will collect, evaluate, and organize information.	1.8
11.8	The student will write, revise, and edit personal and business correspondence to a standard acceptable in the work place and higher education.	1.8
12.1	The student will make a 5-10 minute formal oral presentation.	1.6, 1.7
12.2	The student will evaluate formal presentations.	1.6, 1.7

SCIENCE

ES.1	The student will plan and conduct investigations in which • volume, area, mass, elapsed time, direction, temperature, pressure, distance, density, and changes in elevations/depth are calculated utilizing the most appropriate tools; • technologies, including computer, are used to collect, analyze, and report data and to demonstrate concepts and simulate experimental conditions; • scales, diagrams, maps, charts, graphs, tables, and profiles are constructed and interpreted; • variables are manipulated with repeated trials; and • a scientific viewpoint is constructed and defended.	1.2, 1.4
CH.1	The student will investigate and understand that experiments in which variables are measured, analyzed, and evaluated, produce observations and verifiable data.	1.2, 1.4

DUTY AREA
1. ORIENTING THE STUDENT

COURSE
Precision Machining Technology I (8539)
MAC 106

TASK / COMPETENCY
1.1 Identify machine shop procedures and policies.

PERFORMANCE OBJECTIVE
P1.1 Given introductory materials, text, guides, and a syllabus, identify machine shop procedures and policies. Identification should be made in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M1.1 Instructor-developed written or oral quiz, completed with 100% accuracy

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Review the text, course syllabus, and course objectives.
2. Explain procedure for cleaning and testing the lockers.
3. Check the aprons and glasses.
4. Explain student and teacher responsibilities.

DUTY AREA
1. ORIENTING THE STUDENT

COURSE
Precision Machining Technology I/II
(8539) (8540)
MAC 106

TASK / COMPETENCY
1.2 Demonstrate shop safety and emergency procedures.

PERFORMANCE OBJECTIVE
P1.2 Given the OSHA standards, demonstrate shop safety and emergency procedures, including repairing and adjusting safety equipment, setting up and operating machinery, identifying and correcting safety hazards, and dealing with emergencies.

PERFORMANCE MEASURE
M1.2 Demonstration, all items rated acceptable based on OSHA standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain the repair of safety equipment (e.g., eye-safety shield over the grinding wheel or tool rest).
2. Make repair and adjustments of safety devices.
3. Identify and correct safety hazards in the shop.
4. Identify emergency equipment and procedures.
5. Read material safety data sheet (MSDS) labels on hazardous materials and follow directions exactly.

DUTY AREA
1. ORIENTING THE STUDENT

COURSE
Precision Machining Technology I/II
(8539) (8540)
MAC 106

TASK / COMPETENCY
1.3 Identify machine use and operation.

PERFORMANCE OBJECTIVE
P1.3 Given access to shop machinery, identify machine use and operation. Identification should include procedures for preventative and unscheduled maintenance, use of service manuals for maintenance, replacement of parts, effects of downtime, and initiation of repairs.

PERFORMANCE MEASURE
M1.3 Instructor-prepared checklist, all items rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify procedures for preventative and unscheduled maintenance.
2. Demonstrate use of service manuals and technical publications in relation to machinery maintenance.
3. Explain the factors that allow for economical replacement of parts.
4. Discuss the effects of downtime and the initiation of repairs.
5. Observe demonstrations of proper operation of machines.

DUTY AREA
1. ORIENTING THE STUDENT

COURSE
Precision Machining Technology I/II
(8539) (8540)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
1.4 Inspect the work area to ensure a safe working environment.

PERFORMANCE OBJECTIVE
P1.4 Given safety requirements and access to the work area, inspect the work area to ensure a safe working environment by rating each component on a checklist as "safe" or "unsafe" and stating a reason for the rating.

PERFORMANCE MEASURE
M1.4 Correct rating given for each component according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Inspect and rate as "safe" or "unsafe" the following components of the work area:
   - lighting
   - ventilation
   - overhead clearance
   - use of guards
   - aisles
   - moving area
   - exits
   - fire extinguishers
   - electrical connections
   - electrical cut-offs.
2. Discuss safety requirements for each component.

DUTY AREA
1. ORIENTING THE STUDENT

COURSE
Precision Machining Technology I/II
(8539) (8540)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
1.5 Maintain inventory of supplies and materials needed for machine work.

PERFORMANCE OBJECTIVE
P1.5 Given an inventory list, reorder level, and job specifications, maintain inventory of supplies and materials needed for machine work. The inventory maintenance should include determination of level for supplies and materials, a reorder of necessary supplies, and the establishment of a routine schedule for updating inventory.

PERFORMANCE MEASURE
M1.5 Inventory maintained according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss methods of determining whether it is more economical to repair or replace a defective part.
2. Identify supplies and materials needed to perform normal shop operations and preventative and unscheduled maintenance.
3. Determine inventory on hand.
4. Determine reorder level for supplies and materials.
5. Schedule reorders so that necessary inventory is maintained.
6. Establish a regular routine for updating inventory.

DUTY AREA
1. ORIENTING THE STUDENT

COURSE
Precision Machining Technology I/II
(8539) (8540)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
1.6 Demonstrate positive work attitudes.

PERFORMANCE OBJECTIVE
P1.6 Given information on the attitudes that employers consider positive and specific behaviors that reflect these attitudes, demonstrate positive work attitudes in the classroom and lab. Student must explain the meaning of *positive attitude*, the relationship between a positive attitude and job performance, and the effect of a positive attitude on others in the workplace.

PERFORMANCE MEASURE
M1.6 Instructor-prepared checklist, all items rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Define *positive attitude* and give examples of how it is demonstrated in the workplace.
2. Explain the relationship between a positive attitude and job performance.
3. Explain the effect of a positive attitude on others in the workplace.
4. Invite a personnel director or supervisor to speak about positive work attitudes and their effect on the workforce.

DUTY AREA
1. ORIENTING THE STUDENT

COURSE
Precision Machining Technology I/II
(8539) (8540)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
1.7 Demonstrate an acceptable work ethic.

PERFORMANCE OBJECTIVE
P1.7 Given information about the origins of the work ethic, industry policy related to attendance, punctuality, confidentiality, loyalty, and earning a day's pay for a day's work, demonstrate an acceptable work ethic in the classroom and laboratory. Student must define *work ethic* and review its historical importance, explain industry policies on attendance, punctuality, confidentiality, and loyalty, and identify the responsibilities of a worker in an organization.

PERFORMANCE MEASURE
M1.7 Instructor-prepared checklist based on industry standards, all items rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Define *work ethic* and review its historical importance.
2. Outline industry policies on attendance, punctuality, confidentiality, and loyalty.
3. Identify the responsibilities of a worker in an organization.
4. Invite a personnel director or supervisor to speak about industry policies.
5. Demonstrate industry policies in the classroom and laboratory.

DUTY AREA
1. ORIENTING THE STUDENT

COURSE
Precision Machining Technology I/II
(8539) (8540)
MAC 106

TASK / COMPETENCY
1.8 Determine the importance of advanced training.

PERFORMANCE OBJECTIVE
P1.8 Given information about postsecondary and on-the-job advanced training, determine the importance of advanced training to the worker and industry by completing surveys of available advanced training programs and writing summaries of information provided by guest speakers.

PERFORMANCE MEASURE
M1.8 Student-completed surveys and summaries, made according to instructor-prepared guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss the advantages of advanced training.
2. Invite representatives from industry to speak about job training programs.
3. Invite community college personnel to speak about postsecondary training offerings.
4. Conduct surveys of advanced training programs.

DUTY AREA 2. PERFORMING MATHEMATICAL CALCULATIONS

2.1 Calculate tolerances of allowances for proper fit.
2.2 Calculate indexing a square, hexagon, and a gear blank.
2.3 Calculate machine speeds and feeds by formulas.
2.4 Convert English measurements to metric.
2.5 Determine clearance, relief, and rake of cutting tools.
2.6 Use machining handbooks, charts, and tables to aid in mathematical calculations.
2.7 Convert fractions of an inch to decimal equivalents and vice versa.

RELATED ACADEMIC STANDARDS OF LEARNING
(Based on 1995 SOLs)

MATH		TECHNICAL COMPETENCY
A.1	The student will solve linear equations and inequalities in one variable, solve literal equations (formulas) for a given variable and apply these skills to solve practical problems. Graphing calculators will be used to confirm algebraic solutions.	2.1-2.6
A.2	The student will represent verbal quantitative situations algebraically and evaluate these expressions for given replacement values of the variables. Students will choose an appropriate computational technique, such as mental mathematics, calculator, or paper and pencil.	2.1-2.7
A.3	The student will justify steps used in simplifying expressions and solving equations and inequalities. Justification will include the use of concrete objects, pictorial representations, and the properties of real numbers.	2.1-2.7
G.14	The student, given similar geometric objects, will use proportional reasoning to solve practical problems: investigate relationships between linear, square, and cubic measures; and describe how changes in one of the measures of the object affect the others.	2.1-2.7

DUTY AREA
2. PERFORMING MATHEMATICAL CALCULATIONS

COURSE
Precision Machining Technology I/II (8539)
MAC 107

TASK / COMPETENCY
2.1 Calculate tolerances or allowances for proper fit.

PERFORMANCE OBJECTIVE
P2.1 Given the types of fit required, job specifications, and a *Machinist's Handbook*, calculate tolerances or allowances for proper fit for a specific job, accurate to a bilateral tolerance of ± 0.001".

PERFORMANCE MEASURE
M2.1 Demonstration of calculations, accurate to a bilateral tolerance of ±0.001"

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify types of fits for metal parts.
2. Identify the different tolerances for the types of fit.
3. Explain the difference between positive and negative allowance.
4. Compare the tolerances versus allowances versus deviation.

DUTY AREA
2. PERFORMING MATHEMATICAL CALCULATIONS

COURSE
Precision Machining Technology II(8540)
MAC 107, 209

TASK / COMPETENCY
2.2 Calculate indexing a square, a hexagon, and a gear blank.

PERFORMANCE OBJECTIVE
P2.2 Given a workpiece, job specifications, and references, calculate indexing a square, a hexagon, and a gear blank.

PERFORMANCE MEASURE
M2.2 Demonstration of calculations, completed with at least 80% accuracy

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Determine the diametrical pitch, number of teeth, and blank outside diameter.
2. Calculate indexing for plain indexing head and compound indexing head.

DUTY AREA
2. PERFORMING MATHEMATICAL CALCULATIONS

COURSE
Precision Machining Technology I (8539)
MAC 106

TASK / COMPETENCY
2.3 Calculate machine speeds and feeds by formulas.

PERFORMANCE OBJECTIVE
P2.3 Given cutter specifications, workpiece cutting speed, material, removal rate, and references, calculate machine speeds and feeds by formulas. Speeds must be rounded off to the decimal point and feeds rounded off to the third place past the decimal point to a tolerance of ±0.001".

PERFORMANCE MEASURE
M2.3 Demonstration of calculations, speeds accurate to instructor-specified amount and feeds accurate to a tolerance of ±0.001"

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain and practice solving the appropriate formulas.
2. Determine the diameter and circumference, identify RPM, and explain the formula for SFPM.

DUTY AREA
2. PERFORMING MATHEMATICAL CALCULATIONS

COURSE
Precision Machining Technology I (8539)
MAC 106, 107

TASK / COMPETENCY
2.4 Convert English measurements to metric.

PERFORMANCE OBJECTIVE
P2.4 Given English system linear measurements, job specifications, and reference book, convert English measurements to metric measurements with and without the aid of tables.

PERFORMANCE MEASURE
M2.4 Demonstration of conversion, meets table or chart accuracy

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Determine the degree of accuracy required for conversion.
2. Identify the table or chart that best converts.
3. List in order the prefixes for the metric system.
4. Practice conversions of English measurements to metric measurements (and metric to English) without using tables.

DUTY AREA
2. PERFORMING MATHEMATICAL CALCULATIONS

COURSE
Precision Machining Technology I (8539)
MAC 107

TASK / COMPETENCY
2.5 Determine clearance, relief, and rake of cutting tools.

PERFORMANCE OBJECTIVE
P2.5 Given access to preground cutting tools, a table of cutting angles, and a 6" protractor with rule, determine clearance, relief, and rake of cutting tools, with the angular dimensions accurate within ±1/2°. Demonstration should include measuring angles to a tolerance of ±1°.

PERFORMANCE MEASURE
M2.5 Demonstration of calculations, angular dimensions accurate within ±1/2°

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify tool geometry and why it is necessary.
2. Identify the protractor, explain its purpose, and demonstrate its use.
3. Measure the angles to a tolerance of ±1°.
4. Define *degrees, minutes,* and *seconds.*
5. Identify the reference axis.

DUTY AREA
2. PERFORMING MATHEMATICAL CALCULATIONS

COURSE
Precision Machining Technology I (8539)
MAC 209

TASK / COMPETENCY
2.6 Use machining handbooks, charts, and tables to aid in mathematical calculations.

PERFORMANCE OBJECTIVE
P2.6 Given references and job-related calculation problems, use machining handbooks, charts, and tables to aid in mathematical calculations. Calculations must be accurate according to assigned references.

PERFORMANCE MEASURE
M2.6 Demonstration of calculations, accurate according to assigned references

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Determine the accuracy required.
2. Identify various mathematical charts and tables.
3. Compare the handbooks, charts, and tables.
4. Review mathematical calculations required in Tasks 2.1-2.5.

DUTY AREA
2. PERFORMING MATHEMATICAL CALCULATIONS

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
2.7 Convert common fractions of an inch to decimal fractions and vice versa.

PERFORMANCE OBJECTIVE
P2.7 Given a randomly selected list of common fractions from the total set of 4ths, 8ths, and 16ths, plus 1/32 and 1/64, and a time limit which permits only direct recall, convert common fractions of an inch to decimal fractions. Given a random list of decimal fractions from the same set and a time limit, convert decimal fractions of an inch to common fractions.

PERFORMANCE MEASURE
M2.7 Demonstration of conversions, completed with a minimum accuracy of 85%

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Divide an inch line into progressively smaller common fractions starting with halves and following with 4ths, 8ths, etc., down to 64ths.
2. Label the common-fractions-of-an-inch line.
3. List the decimal equivalents of each common fraction of an inch down to 16ths.
4. Divide an inch into decimal fractions down to .025" (layout should be similar to that found on inch micrometer barrels).
5. Label each decimal fraction of an inch down to .025".

DUTY AREA 3. MEASURING AND PERFORMING LAYOUT

3.1 Measure, using a machinist's combination set.
3.2 Measure, using a machinist's rule.
3.3 Measure, using a rule depth gage and a micrometer depth gauge.
3.4 Measure, using a venire caliper and a dial caliper.
3.5 Measure, using a dial indicator.
3.6 Measure, using an inside micrometer.
3.7 Measure, using an outside micrometer.
3.8 Measure, using various gauges and templates.
3.9 Determine the accuracy of precision measurement instruments.
3.10 Measure, using a universal bevel protractor.
3.11 Measure, using a sine bar.
3.12 Perform layout for precision machine work.
3.13 Measure, using a height gauge.
3.14 Measure, using a bore gauge.
3.15 Measure, using a coordinate measuring machine.
3.16 Measure, using an optical comparator.

RELATED ACADEMIC STANDARDS OF LEARNING

(Based on 1995 SOLs)

MATH		TECHNICAL COMPETENCY
G.2	The student will use pictorial representations, including computer software and coordinate methods to solve problems involving symmetry and transformation.	3.15
G.7	The student will solve practical problems involving right triangles by using the Pythagorean Theorem and its converse, properties of special right triangles, and right triangle trigonometry. Calculations will be used to solve problems and find decimal approximations for the solutions.	3.16
G.9	The student will use measures of interior and exterior angles of polygons to solve problems. Tessellations and tiling problems will be used to make connections to art, construction, and nature.	3.1
G.12	The student will make a model of a three-dimensional figure from a two-dimensional drawing and make a two-dimensional representation of a three-dimensional object. Models and representations will include scale drawings, perspective drawings, blueprints, or computer simulations.	3.12
G.14	The student, given similar geometric objects, will use proportional reasoning to solve practical problems: investigate relationships between linear, square, and cubic measures; and describe how changes in one of the measures of the object affect the others.	3.1, 3.2, 3.8, 3.12, 3.16
T.8	The student will solve trigonometric equations that include both infinite solutions and restricted domain solutions and solve basic trigonometric inequalities. Graphing utilities will be used to solve equations, to check for reasonableness of results, and to verify algebraic solutions.	3.11, 3.15
T.9	The student will identify, create, and solve practical problems involving triangles and vectors. Techniques will include using the trigonometric functions, the Pythagorean Theorem, the Law of Sines, and the Law of Cosines.	3.11, 3.15

SCIENCE

PH.1 The student will investigate and understand how to plan and conduct investigations in which 3.4

- the components of a system are defined;
- instruments are selected and used to extend observations and measurements of mass, volume, temperature, heat exchange, energy transformations, motion, fields, and electric charge;
- information is recorded and presented in an organized format;
- metric units are used in all measurements and calculations;
- the limitations of the experimental apparatus and design are recognized;
- the limitations of measured quantities through the appropriate use of significant figures or error ranges are recognized; and
- data gathered from non-SI instruments are incorporated through appropriate conversions.

DUTY AREA
3. MEASURING AND PERFORMING LAYOUT

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
3.1 Measure, using a machinist's combination set.

PERFORMANCE OBJECTIVE
P3.1 Given a combination set, a cylindrical workpiece, an angular workpiece, a piece of stock to be machined, a blueprint, and a can of layout fluid, measure, using a machinist's combination set. The measurements should include finding the center of a cylindrical workpiece, measuring an angle with the protractor head, checking a workpiece for being square, checking a 45° angle for accuracy, and laying out a workpiece to be machined. Linear measurements must be accurate within ± 1/64" and angular measurements accurate within ± 1°. Measurements must be recorded accurately.

PERFORMANCE MEASURE
M3.1 Demonstration of measurements outlined above, accurate within ±1/64" for linear measurements and within ±1° for angular measurements

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Measure the given parts with a combination set.
2. Do the layout according to blueprint.
3. Lay out the required operations for machining.

DUTY AREA
3. MEASURING AND PERFORMING LAYOUT

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
3.2 Measure, using a machinist's rule.

PERFORMANCE OBJECTIVE
P3.2 Given a blueprint, a machined part, and a 6" steel rule, measure, using a machinist's rule. All dimensions must be measured to an accuracy of ±1/64" to determine whether the part satisfies blueprint specifications, and measurements must be recorded accurately.

PERFORMANCE MEASURE
M3.2 Demonstration of measurements, to an accuracy of ±1/64"

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Use the proper holding and marking techniques for measuring a given part.
2. Record and compare measurement of each feature with the blueprint specifications.

DUTY AREA
3. MEASURING AND PERFORMING LAYOUT

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
3.3 Measure, using a rule depth gauge and a micrometer depth gauge.

PERFORMANCE OBJECTIVE
P3.3 Given a drilled and counterbored workpiece, measure, using a rule depth gauge and a micrometer depth gauge. Rule depth gauge measurements must be accurate to a tolerance of ± 1/64" and micrometer depth gauge measurements to a tolerance of ± 0.001". Measurements must be recorded accurately.

PERFORMANCE MEASURE
M3.1 Demonstration of measurements, to a tolerance of ±1/64" for the rule depth gauge and ±0.001" for the micrometer depth gauge

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Clean the reference surface.
2. Take measurements with the rule depth gauge.
3. Insert the appropriate length extension rod in the micrometer depth gauge.
4. Take measurements with the micrometer depth gauge, using the appropriate pressure.
5. Record measurements.

DUTY AREA
3. MEASURING AND PERFORMING LAYOUT

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
3.4 Measure, using a vernier caliper and a dial caliper.

PERFORMANCE OBJECTIVE
P3.4 Given several pieces of flat and round stock, measure, using a vernier caliper and a dial caliper, the thickness and/or diameter of each piece to an accuracy of ±0.001". All measurements must be recorded accurately.

PERFORMANCE MEASURE
M3.4 Demonstration of measurements, to an accuracy of ±0.001"

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Measure the stock with vernier calipers.
2. Measure the stock with dial calipers.
3. Record measurements according to listed numbers, using vernier or dial calipers.

DUTY AREA
3. MEASURING AND PERFORMING LAYOUT

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
3.5 Measure, using a dial indicator.

PERFORMANCE OBJECTIVE
P3.5 Given a workpiece and holding device, measure, using a dial indicator. Workpiece must be aligned with the dial indicator to a tolerance of ±0.001", and measurements must be recorded accurately.

PERFORMANCE MEASURE
M3.5 Demonstration of measurements, to a tolerance of ±0.001"

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Mount the dial indicator to the work-holding device.
2. Adjust the workpiece to the appropriate tolerance.
3. Record measurements.

DUTY AREA
3. MEASURING AND PERFORMING LAYOUT

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
3.6 Measure, using an inside micrometer.

PERFORMANCE OBJECTIVE
P3.6 Given a workpiece with a large slot or bore, measure, using an inside micrometer, the slot or bore to an accuracy of ±0.001". Measurements must be recorded accurately.

PERFORMANCE MEASURE
M3.6 Demonstration of measurements, to a tolerance of ±0.001"

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate use of an inside micrometer.
2. Record the reading of the inside micrometer taken from the workpiece.

DUTY AREA
3. MEASURING AND PERFORMING LAYOUT

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
3.7 Measure, using an outside micrometer.

PERFORMANCE OBJECTIVE
P3.7 Given several pieces of flat and round stock and a micrometer caliper, measure, using an outside micrometer, the thickness and/or diameter of each piece, with an accuracy of ±0.001". Measurements must be recorded accurately.

PERFORMANCE MEASURE
M3.7 Demonstration of measurements, to an accuracy of ±0.001"

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate use of an outside micrometer.
2. Take readings from given stock with an outside micrometer.
3. Record readings taken from different size materials.

DUTY AREA
3. MEASURING AND PERFORMING LAYOUT

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
3.8 Measure, using various gauges and templates.

PERFORMANCE OBJECTIVE
P3.8 Given parts and specifications, measure using various gauges and templates, the parts to ±1/64" or other specified tolerance. Measurements must be recorded accurately.

PERFORMANCE MEASURE
M3.8 Demonstration of measurements, to ±1/64" or other specified tolerance

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. List the various sizes and types of gauges.
2. Demonstrate the use of various gauges.
3. Record measurements of different parts.

DUTY AREA
3. MEASURING AND PERFORMING LAYOUT

COURSE
Precision Machining Technology II (8540)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
3.9 Determine the accuracy of precision measurement instruments.

PERFORMANCE OBJECTIVE
P3.9 Given gauge blocks and other master references, determine the accuracy of precision measurement instruments, within a tolerance of ±0.001" at a temperature of 68°-75° Fahrenheit. Measurements must be recorded accurately.

PERFORMANCE MEASURE
M3.9 Demonstration of determination of accuracy, within a tolerance of ±0.001" at a temperature of 68°-75° Fahrenheit

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate checking the accuracy of selected precision measurement instruments with gauge blocks.
2. Record the accuracy of given instruments.

DUTY AREA
3. MEASURING AND PERFORMING LAYOUT

COURSE
Precision Machining Technology II (8540)
MAC 106

TASK / COMPETENCY
3.10 Measure, using a universal bevel protractor.

PERFORMANCE OBJECTIVE
P3.10 Given various parts and specifications, measure, using a universal bevel protractor, designated angles to within an accuracy of 5 minutes. Measurements must be recorded accurately.

PERFORMANCE MEASURE
M3.10 Demonstration of measurements, to an accuracy of within 5 minutes

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate use of protractor.
2. List and record measurements.

DUTY AREA
3. MEASURING AND PERFORMING LAYOUT

COURSE
Precision Machining Technology II (8540)
MAC 209

TASK / COMPETENCY
3.11 Measure, using a sine bar.

PERFORMANCE OBJECTIVE
P3.11 Given a surface plate, gauge blocks, precision measurement instruments, a *Machinist's Handbook*, job specifications, and workpiece, measure, using a sine bar, the angle of the workpiece to within 5 minutes. Measurements must be recorded accurately.

PERFORMANCE MEASURE
M3.11 Demonstration of measurements, to an accuracy of within 5 minutes

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Clean, set up, and measure given angles of the workpiece.
2. List the readings in degrees and minutes.
3. Take readings from tables in the handbook of trigonometry functions.

DUTY AREA
3. MEASURING AND PERFORMING LAYOUT

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
3.12 Perform layout for precision machine work.

PERFORMANCE OBJECTIVE
P3.12 Given a blueprint, workpiece, surface plate, cleaner, layout fluid, mounting devices, layout tools, and precision measurement devices, perform layout for precision machine work. Layout must conform to the specifications given on the blueprint.

PERFORMANCE MEASURE
M3.12 Demonstration of layout, with location of the positions accurate within ±1/64" and the angles accurate within ±1°

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Interpret the blueprint data, and transfer the measurements to the actual stock.
2. Use gauges, indicators, and the sine bar in the layout.
3. List the functions of the layout equipment, devices, and instruments.
4. Demonstrate care of surface plate.

DUTY AREA
3. MEASURING AND PERFORMING LAYOUT

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
3.13 Measure, using a height gauge.

PERFORMANCE OBJECTIVE
P3.13 Given a blueprint, workpiece, cleaner, scribe, points, gauge block, precision measurement instruments, and dial indicator, measure, using a height gauge, to determine the accuracy of the layout measurements to a tolerance of ±0.005".

PERFORMANCE MEASURE
M3.13 Demonstration of measurements, to a tolerance of ±0.005"

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Interpret blueprint specifications of given workpieces.
2. Measure workpieces with a height gauge.
3. Demonstrate checking the layout measurements with a height gauge.
4. Demonstrate procedures for cleaning and setting up layout work.

DUTY AREA
3. MEASURING AND PERFORMING LAYOUT

COURSE
Precision Machining Technology II (8540)
MAC 107

TASK / COMPETENCY
3.14 Measure, using a bore gauge.

PERFORMANCE OBJECTIVE
P3.14 Given parts and specifications, measure, using a bore gauge, the parts to a specified tolerance. Measurements must be accurately recorded.

PERFORMANCE MEASURE
M3.14 Demonstration of measurements, to ±0.002" or other specified tolerance

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Select and install correct measuring tip.
2. Set bore gauge to a specified size.
3. Obtain measurements of different parts.
4. Record measurements of parts.

DUTY AREA
3. MEASURING AND PERFORMING LAYOUT

COURSE
Precision Machining Technology I (8539)
MAC 205, 209

TASK / COMPETENCY
3.15 Measure, using a coordinate measuring machine.

PERFORMANCE OBJECTIVE
P3.15 Given parts and specifications, measure, using a coordinate measuring machine, the parts to specified tolerance. Measurements must be accurately recorded.

PERFORMANCE MEASURE
M3.15 Demonstration of measurements, to ±0.001" or other specified tolerance

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Set up coordinate measuring machine.
2. Measure a variety of machine parts.
3. Record measurements of different parts.

DUTY AREA
3. MEASURING AND PERFORMING LAYOUT

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
3.16 Measure, using an optical comparator.

PERFORMANCE OBJECTIVE
P3.16 Given parts and specifications, measure, using an optical comparator, the parts to specified tolerance. Measurements must be accurately recorded.

PERFORMANCE MEASURE
M3.16 Demonstration of measurements, to specified tolerance

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Set up optical comparator.
2. Measure a variety of machine parts.
3. Record measurements of different parts.

DUTY AREA 4. PRODUCING AND INTERPRETING DRAWINGS

4.1 Interpret industrial drawings.
4.2 Demonstrate the use of selected drafting and sketching equipment.
4.3 Demonstrate line-sketching technique.
4.4 Sketch straight lines.
4.5 Construct angles.
4.6 Construct plane figures.
4.7 Construct circles and arcs.
4.8 Sketch orthographic views.
4.9 Sketch multiview projections.
4.10 Sketch auxiliary views.
4.11 Sketch standard sections.
4.12 Sketch special sections.

RELATED ACADEMIC STANDARDS OF LEARNING
(Based on 1995 SOLs)

MATH		TECHNICAL COMPETENCY
G.4	The student will use the relationships between angles formed by two lines cut by a transversal to determine if two lines are parallel and verify, using algebraic and coordinate methods as well as deductive proofs.	4.4
G.9	The student will use measures of interior and exterior angles of polygons to solve problems. Tessellations and tiling problems will be used to make connections to art, construction, and nature.	4.5
G.11	The student will construct, using a compass and straightedge, a line segment congruent to a given line segment, the bisector of a line segment, a perpendicular to a given line from a point not on the line, a perpendicular to a given line from a point on the line, the bisector of a given angle, and an angle congruent to a given angle.	4.4, 4.8
G.12	The student will make a model of a three-dimensional figure from a two-dimensional drawing and make a two-dimensional representation of a three-dimensional object. Models and representations will include scale drawings, perspective drawings, blueprints, or computer simulations.	4.8, 4.9
SCIENCE		
PH.2	The student will investigate and understand how to analyze and interpret data.	4.5
PH.5	The student will investigate and understand the interrlationships among mass, distance, force, and time through mathematical and experimental processes.	4.5

DUTY AREA
4. PRODUCING AND INTERPRETING DRAWINGS

COURSE
Precision Machining Technology I (8539)
MAC 106, DRF 162

TASK / COMPETENCY
4.1 Interpret industrial drawings.

PERFORMANCE OBJECTIVE
P4.1 Given an industrial drawing, interpret the drawing and any notes or bills of material that may be attached. Interpretation should include noting the appropriate tools and materials for the job and planning all details of the job to specification. Demonstration should conform to established standards for a usable manufacturing plan.

PERFORMANCE MEASURE
M4.1 Demonstration, meeting all established standards as specified in instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify title blocks, parts lists, and notes.
2. Interpret various standardized lines in drawings.
3. Interpret various standardized views.
4. Explain dimensions and tolerances.
5. Explain sections.
6. Enumerable symbols.
7. Identify various standardized projections.

DUTY AREA
4. PRODUCING AND INTERPRETING DRAWINGS

COURSE
Precision Machining Technology II (8540)

TASK / COMPETENCY
4.2 Demonstrate the use of selected drafting and sketching equipment.

PERFORMANCE OBJECTIVE
P1.2 Given paper, a drafting board and T-square, or a drafting station, demonstrate the use of selected drafting and sketching equipment. Demonstration must include use of inch and metric scales and templates, vernier scales and protractors, and a compass, in accordance with established standards.

PERFORMANCE MEASURE
M4.2 Demonstration, in accordance with established standards for a usable manufacturing sketch as specified in instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Use inch and metric scales and templates.
2. Measure angles using vernier scales or protractors.
3. Create arcs and circles using scales, templates, or a compass.

DUTY AREA
4. PRODUCING AND INTERPRETING DRAWINGS

COURSE
Precision Machining Technology I (8539)
EGR 111

TASK / COMPETENCY
4.3 Demonstrate line-sketching technique.

PERFORMANCE OBJECTIVE
P4.3 Given a drafting station or board and standard drafting equipment, demonstrate line-sketching technique by constructing lines, arcs, and circles. Drawings must conform to established standards.

PERFORMANCE MEASURE
M4.3 Student-produced drawings, all components meeting established standards as specified in instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Construct straight lines.
2. Construct circles and arcs.
3. Use acceptable line weights.

DUTY AREA
4. PRODUCING AND INTERPRETING DRAWINGS

COURSE
Precision Machining Technology I (8539)
EGR 111

TASK / COMPETENCY
4.4 Sketch straight lines.

PERFORMANCE OBJECTIVE
P4.4 Given various geometric exercises and standard drafting equipment, sketch straight lines. Drawings must include parallel and perpendicular lines, the division of a line into equal parts, and the division of an angle into two equal angles, in accordance with established standards.

PERFORMANCE MEASURE
M4.4 Student-produced drawings, all components meeting established standards as specified in instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Divide an angle into two equal angles, using a compass.
2. Sketch a line that is parallel to a given line, through a given point, and at a given distance from the original line.
3. Sketch a line and divide it into a specified number of equal parts.
4. Sketch a line perpendicular to a given line from a point.
5. Sketch a line perpendicular through a point on a line.

DUTY AREA
4. PRODUCING AND INTERPRETING DRAWINGS

COURSE
Precision Machining Technology I (8539)
EGR 111

TASK / COMPETENCY
4.5 Construct angles.

PERFORMANCE OBJECTIVE
P4.5 Given various exercises and drawings and standard drafting equipment, construct angles using geometric construction principles. Drawings must include a triangle with sides given, an equilateral triangle with one side given, and a right angle, in accordance with established standards.

PERFORMANCE MEASURE
M4.5. Student-produced drawings, all components meeting established standards as specified in instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Construct a triangle with sides given.
2. Construct right angles.
3. Construct an equilateral triangle with one side given.

DUTY AREA
4. PRODUCING AND INTERPRETING DRAWINGS

COURSE
Precision Machining Technology I (8539)
EGR 111

TASK / COMPETENCY
4.6 Construct plane figures.

PERFORMANCE OBJECTIVE
P4.6 Given various exercises and drawings and standard drafting equipment, construct plane figures using geometric construction principles. Drawings should include a square, a rectangle, a circle with inscribed hexagon, a hexagon with distance across flat sides given, and a pentagon inscribed in a circle, in accordance with established standards.

PERFORMANCE MEASURE
M4.6 Student-produced drawings, all components meeting established standards as specified in instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Construct a square.
2. Construct a rectangle.
3. Construct a circle and inscribe a hexagon.
4. Construct a hexagon with distance across flat sides given.
5. Construct a pentagon by inscribing in a circle.

DUTY AREA
4. PRODUCING AND INTERPRETING DRAWINGS

COURSE
Precision Machining Technology I (8539)
EGR 111

TASK / COMPETENCY
4.7 Construct circles and arcs.

PERFORMANCE OBJECTIVE
P4.7 Given various geometric exercises and drawings and standard drafting equipment, construct circles and arcs using geometric construction principles. Drawings should include a circle through three given points and an arc tangent to specified angles, in accordance with established standards.

PERFORMANCE MEASURE
M4.7 Student-produced drawings, all components meeting established standards as specified in instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Construct a circle through three given points.
2. Construct an arc tangent to specified angles.

DUTY AREA
4. PRODUCING AND INTERPRETING DRAWINGS

COURSE
Precision Machining Technology I (8539)
EGR 111

TASK / COMPETENCY
4.8 Sketch orthographic views.

PERFORMANCE OBJECTIVE
P4.8 Given a mechanical part or pictorial drawing and standard drafting equipment, sketch the necessary orthographic views of the part. Drawings should include a 2-view sketch and a 3-view sketch, in accordance with ANSI standards.

PERFORMANCE MEASURE
M4.8 Student-produced drawings, all components meeting ANSI standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Make a 2-view sketch.
2. Make a 3-view sketch.
3. Read appropriate technical material.

DUTY AREA
4. PRODUCING AND INTERPRETING DRAWINGS

COURSE
Precision Machining Technology I (8539)
EGR 111

TASK / COMPETENCY
4.9 Sketch multiview projections.

PERFORMANCE OBJECTIVE
P4.9 Given pictorial views, mechanical parts, or sketches, and standard drafting equipment, sketch multiview projections of the parts. Drawings should include top, left, and right side views, missing visible and hidden lines, and 1-, 2-, and 3-view drawings, in accordance with ANSI standards.

PERFORMANCE MEASURE
M4.9 Student-produced drawings, all components meeting ANSI standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify types of planes and projection lines in orthographic views.
2. Construct top, left, and right side views.
3. Construct missing visible and hidden lines.
4. Construct circles and arcs, using a template.
5. Construct 1-, 2-, and 3-view drawings.
6. Construct fillets, rounds, and runouts.

DUTY AREA
4. PRODUCING AND INTERPRETING DRAWINGS

COURSE
Precision Machining Technology I (8539)
EGR 111

TASK / COMPETENCY
4.10 Sketch auxiliary views.

PERFORMANCE OBJECTIVE
P4.10 Given standard drafting equipment and a mechanical part, a sketch, or a multiview or pictorial drawing, sketch auxiliary views. Drawings should include true-size auxiliary views of a curved surface and of an oblique plane, a primary auxiliary view of an inclined plane, and a secondary auxiliary view of an object, in accordance with established standards.

PERFORMANCE MEASURE
M4.10 Student-produced drawings, all components meeting established standards as specified in instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Construct a primary auxiliary view of an inclined plane.
2. Construct a true-size auxiliary view of a curved surface.
3. Construct a true length of an oblique surface.
4. Determine the true angle and slope of a line.
5. Determine the true angle between two planes.
6. Construct a secondary auxiliary view of an object.
7. Construct the point view of a line.
8. Construct the true-size auxiliary view of an oblique plane.

DUTY AREA
4. PRODUCING AND INTERPRETING DRAWINGS

COURSE
Precision Machining Technology II (8539)
EGR 111

TASK / COMPETENCY
4.11 Sketch standard sections.

PERFORMANCE OBJECTIVE
P4.11 Given standard drafting equipment and mechanical parts, sketches, or multiview or pictorial drawings, sketch standard sections by preparing and dimensioning a drawing with section and conventional views. Views should include a full section, a half section, and an offset section of objects, in accordance with ANSI standards.

PERFORMANCE MEASURE
M4.11 Student-produced drawings, all components meeting ANSI standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Construct a full section of an object.
2. Construct a half section of an object.
3. Construct an offset section of an object.

DUTY AREA
4. PRODUCING AND INTERPRETING DRAWINGS

COURSE
Precision Machining Technology II (8539)
EGR 111

TASK / COMPETENCY
4.12 Sketch special sections.

PERFORMANCE OBJECTIVE
P4.12 Given standard drafting equipment and mechanical parts, sketches, or multiview or pictorial drawings, sketch special sections by preparing and dimensioning a drawing with section and conventional views. Views should include a broken-out section, a removed section, a revolved section, a rib section, an aligned section, and an assembly section, in accordance with ANSI standards.

PERFORMANCE MEASURE
M4.12 Student-produced drawings, all components meeting ANSI standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Construct a broken-out section of an object.
2. Construct a removed section of an object.
3. Construct a revolved section of an object.
4. Construct a rib section of an object.
5. Construct an aligned section of an object with holes, ribs, or spokes.
6. Construct adjacent parts in an assembly section.
7. Construct an assembly section.

DUTY AREA 5. PERFORMING BENCH WORK

5.1 Cut materials with a hand hacksaw.
5.2 Cut threads, using hand taps.
5.3 Cut threads, using dies.
5.4 Disassemble and assemble parts.
5.5 Hand-sharpen cutting tools, using abrasive stones.
5.6 Ream holes, using hand reamers.
5.7 Remove dameaged screws and other non-hardened thread hardware.
5.8 Work and shape metal, using hand tools.
5.9 Clamp the work in a holding device.
5.10 Perform bench filing.

RELATED ACADEMIC STANDARDS OF LEARNING

(Based on 1995 SOLs)

MATH		TECHNICAL COMPETENCY
T.9	The student will identify, create, and solve practical problems involving triangles and vectors. Techniques will include using the trigonometric functions, the Pythagorean Theorem, the Law of Sines, and the Law of Cosines.	5.3

DUTY AREA
5. PERFORMING BENCH WORK

COURSE
Precision Machining Technology I (8539)
MAC 106,107

TASK / COMPETENCY
5.1 Cut materials with a hand hacksaw.

PERFORMANCE OBJECTIVE
P5.1 Given hacksaw blades (24- and 32-pitch), hacksaw frame, work-holding device, aluminum pipe, sheet metal stock, and job specifications, cut materials with a hand hacksaw. Cuts must follow scribed lines according to job specifications and be performed in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M5.1 Demonstration, cuts accurate according to job specifications and procedure rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate mounting of the blade.
2. Demonstrate selection of the blade for the material to be cut.
3. Demonstrate procedure for holding and cutting with a hacksaw.
4. Demonstrate safe work-holding procedures and devices for the stock being cut.
5. Demonstrate the use of a vise.
6. Demonstrate the use of cutting tools, blades, and accessories.

DUTY AREA
5. PERFORMING BENCH WORK

COURSE
Precision Machining Technology I (8539)
MAC 106

TASK / COMPETENCY
5.2 Cut threads, using hand taps.

PERFORMANCE OBJECTIVE
P5.2 Given a blueprint, workpiece, holding device, lubricant, assortment of drills, center punch, taper, plug and bottoming taps, tap wrench, references or tables, and a square, cut threads, using hand taps, to blueprint specifications. Demonstration must be performed in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M5.2 Demonstration, cuts accurate according to blueprint specifications and procedure rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Determine the specifications from the blueprint, including the necessary metrics.
2. Explain why accuracy in layout is essential.
3. Determine the tap drill size for the standard and metric series.
4. Determine the type of tap holder for the size of the tap.
5. Demonstrate the use of taper, plug, and bottoming taps.

DUTY AREA
5. PERFORMING BENCH WORK

COURSE
Precision Machining Technology I (8539)
MAC 106

TASK / COMPETENCY
5.3 Cut threads, using dies.

PERFORMANCE OBJECTIVE
P5.3 Given a blueprint, workpiece, vise, dies, diestock, cutting oil, files, and rule, cut threads, using dies, to the blueprint specifications and accurate within ±1/64" of the required length. Demonstration must be performed in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M5.3 Demonstration, accurate within ±1/64" of the required length and all items on instructor-prepared checklist rated acceptable

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain the types of dies (e.g., solid, split, right-hand, and left-hand).
2. Identify the sizes of threading dies, and cut a thread with a die technique and methodology.
3. Distinguish the front from the back of the die.
4. Demonstrate the mounting of the die in a die holder.
5. Determine the fit and how the pitch or type of die ensures the fit.
6. Explain the pitch and thread.
7. Identify the proper major diameter.

DUTY AREA
5. PERFORMING BENCH WORK

COURSE
Precision Machining Technology I (8539)
MAC 206

TASK / COMPETENCY
5.4 Disassemble and assemble parts.

PERFORMANCE OBJECTIVE
P5.4 Given a manufacturer's repair manual or job specifications and specific parts, disassemble and assemble parts according to the manual or job specifications. Demonstration must be performed in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M5.4 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate how to mark, measure, and identify the parts, including the sketches, that will assist in reassembly.
2. Demonstrate using and testing precision measurement equipment.

DUTY AREA
5. PERFORMING BENCH WORK

COURSE
Precision Machining Technology I (8539)
MAC 106, 107

TASK / COMPETENCY
5.5 Hand-sharpen cutting tools, using abrasive stones.

PERFORMANCE OBJECTIVE
P5.5 Given job specifications, an assortment of cutting tools, oilstones (hones) box, slip stones, and lubricants, hand-sharpen cutting tools, using abrasive stones. Tools must be sharpened according to the job specifications, and demonstration must be completed in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M5.5 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate and explain how to select the cutter sharpener.
2. Demonstrate sharpening to job specifications.
3. Inspect the cutter.
4. Clean the sharpener.

DUTY AREA
5. PERFORMING BENCH WORK

COURSE
Precision Machining Technology I (8539)
MAC 106

TASK / COMPETENCY
5.6 Ream holes, using hand reamers.

PERFORMANCE OBJECTIVE
P5.6 Given a blueprint, workpiece, work-holding device, reamers, taps, tap wrench, lubricant, drill press, and lathe center, ream holes, using hand reamers, to a tolerance of ±0.001". Demonstration must be performed in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M5.6 Demonstration, holes reamed to a tolerance of ±0.001" and all items on instructor-prepared checklist rated acceptable

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate hand-reaming, using the following procedures:
   a. Secure a workpiece to the work-holding device.
   b. Select the proper reamer.
   c. Mount the reamer in the tap wrench and lubricate, if applicable.
   d. Hand ream to specifications.
2. Demonstrate hand-reaming with a drill press, using the following procedures:
   a. Follow steps b. and c. above (hand-reaming).
   b. Mount the lathe center to the drill press spindle.
   c. Align the center to the tap wrench and lubricate, if necessary.
   d. Hand ream to specifications.

DUTY AREA
5. PERFORMING BENCH WORK

COURSE
Precision Machining Technology I (8539)
MAC 151, 206

TASK / COMPETENCY
5.7 Remove damaged screws and other non-hardened thread hardware.

PERFORMANCE OBJECTIVE
P5.7 Given an electric drill, an assortment of drill bits, center punch, chuck key, tap, wrench, screw extractor, workpiece, and work-holding device, remove damaged screws and other non-hardened thread hardware from the workpiece, maintaining the fit of the original tapped hole. Demonstration must be performed in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M5.7 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate securing the workpiece in the work-holding device.
2. Select the drill and center punch, and drill the hole in the damaged part.
3. Place the screw extractor in the hole.
4. Remove the damaged part.
5. Inspect the threads in the hole, retapping if necessary.

DUTY AREA
5. PERFORMING BENCH WORK

COURSE
Precision Machining Technology I (8539)
MAC 106

TASK / COMPETENCY
5.8 Work and shape metal, using hand tools.

PERFORMANCE OBJECTIVE
P5.8 Given a blueprint, workpiece, work-holding device, cutter bits, portable grinder, chuck wrench, portable drill with tool and attachments, hand chisels, punches, hammers, and appropriate measurement devices, work and shape metal, using hand tools. Workpiece must be worked and shaped to blueprint specifications, and demonstration must be completed in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M5.8 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate using highspeed portable grinders, using the following procedures:
   a. Secure the cutting bit in the chuck.
   b. Secure the workpiece in the holding device.
   c. Shape the workpiece.
2. Demonstrate shaping and working to specifications, using the following procedures:
   a. Use a portable hand drill with the proper tool attachments.
   b. Select and use sharpened hand chisels, punches, and hammers.
   c. Shape and work to job specifications, measuring for accuracy.

DUTY AREA
5. PERFORMING BENCH WORK

COURSE
Precision Machining Technology I (8539)
MAC 106

TASK / COMPETENCY
5.9 Clamp the work in a holding device.

PERFORMANCE OBJECTIVE
P5.9 Given a workpiece, holding device, and tools, clamp the work in a holding device, according to instructor's guidelines. Proper holding device must be selected for the workpiece, and all safety precautions must be observed.

PERFORMANCE MEASURE
M5.9 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify the types and sizes of holding devices.
2. Identify the accessories for a holding device.
3. Select the proper holding device and attachments for the workpiece.
4. Secure the holding device to the table.
5. Secure the workpiece in the holding device.
6. Check for level, squareness, and angle.
7. Explain the safety precautions necessary when using a holding device.

DUTY AREA
5. PERFORMING BENCH WORK

COURSE
Precision Machining Technology I (8539)
MAC 106

TASK / COMPETENCY
5.10 Perform bench filing.

PERFORMANCE OBJECTIVE
P5.10 Given an assortment of files, file handles, file cards, vises, false jaws, steel square, bevel protractor, measurement instruments, workpieces, and a blueprint, perform bench filing. Workpieces must be filed to blueprint specifications, and demonstration must be completed in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M5.10 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain how to select the appropriate file.
2. Check the file handle.
3. Clean the file.
4. Mount the workpiece.
5. Test the flatness or angle of the work.
6. Check for pinning.

DUTY AREA 6. PROCESSING METALS

6.1 Identify ferrous and nonferrous metals.
6.2 Determine metal type by color code or spark test.
6.3 Use hardening processes.
6.4 Use softening processes.
6.5 Case-harden metals.
6.6 Temper metals.
6.7 Surface-harden metals.

DUTY AREA
6. PROCESSING METALS

COURSE
Precision Machining Technology I (8539)
MAC 146

TASK / COMPETENCY
6.1 Identify ferrous and nonferrous metals.

PERFORMANCE OBJECTIVE
P6.1 Given a number of different metal samples, identify ferrous and nonferrous metals by naming and classifying at least 80% of the samples correctly. Identification should be made in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M6.1 Instructor-prepared test, at least 80% of the given samples identified correctly

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Define *ferrous* and *nonferrous*.
2. Identify pieces of metal by shape, sheet, rolled, square, bands, and angle.
3. Identify differences between ferrous and nonferrous metals.
4. List qualities and proportioning of various alloys.

DUTY AREA
6. PROCESSING METALS

COURSE
Precision Machining Technology I (8539)
MAC 146

TASK / COMPETENCY
6.2 Determine metal type by color code or spark test.

PERFORMANCE OBJECTIVE
P6.2 Given a grinder, color code chart, and pieces of ferrous stock, determine metal type by color code or spark test for at least 80% of the given pieces. Identification should be made in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M6.2 Demonstration, at least 80% of the given pieces of ferrous stock identified correctly

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify a piece of steel, using the color code chart or spark test.
2. Explain the SAE (Society of Automotive Engineers) number system and the AISI (American Iron and Steel Institute) system.
3. Explain safety rules.

DUTY AREA
6. PROCESSING METALS

COURSE
Precision Machining Technology I (8539)
MAC 146, 205

TASK / COMPETENCY
6.3 Use hardening processes.

PERFORMANCE OBJECTIVE
P6.3 Given hardness specifications for a piece of metal, use hardening processes to harden the metal to AISI (American Iron and Steel Institute) specifications. Demonstration must include setting up hardening equipment and accessories, selecting the appropriate hardening process, selecting the color of steel at the proper temperature, and observing necessary safety precautions.

PERFORMANCE MEASURE
M6.3 Demonstration of metal hardening to AISI specifications, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify heat-treating processes.
2. Identify hot-working processes.
3. Identify cold-working processes.
4. Select the color of steel at the proper temperature.
5. Select the proper specifications from the AISI chart.
6. Identify safety precautions in hardening processes.
7. Set up hardening equipment and accessories.

DUTY AREA
6. PROCESSING METALS

COURSE
Precision Machining Technology I (8539)
MAC 146

TASK / COMPETENCY
6.4 Use softening processes.

PERFORMANCE OBJECTIVE
P6.4 Given softening or stress-relaxation specifications and identified hardened metal parts, use softening processes. Demonstration must include selecting the appropriate softening process and observing necessary safety precautions.

PERFORMANCE MEASURE
M6.4 Demonstration of metal softening to specifications provided by the instructor, rated acceptable on instructor-provided checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify the material to be softened.
2. Identify annealing, normalizing, and stress-relieving processes.
3. Identify the heating method.
4. Identify the cooling method.
5. Describe safety precautions.

DUTY AREA
6. PROCESSING METALS

COURSE
Precision Machining Technology I (8539)
MAC 146

TASK / COMPETENCY
6.5 Case-harden metals.

PERFORMANCE OBJECTIVE
P6.5 Given designated parts, case-harden metals to AISI specifications. Demonstration should include identifying by grade the materials to be hardened, selecting and setting up necessary hardening equipment, and observing necessary safety precautions.

PERFORMANCE MEASURE
M6.5 Demonstration of case-hardening to AISI specifications, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify by grade the materials to be hardened.
2. Identify carbonizing, cyaniding, and nitriding processes.
3. Determine the equipment needed for hardening processes.
4. Identify safety hazards and precautions.

DUTY AREA
6. PROCESSING METALS

COURSE
Precision Machining Technology I (8539)
MAC 146

TASK / COMPETENCY
6.6 Temper metals.

PERFORMANCE OBJECTIVE
P6.6 Given hardened metal and tempering equipment, temper the metal to the tolerance specified on instructor-provided charts. Demonstration should include identifying the color of the metal for the temperature range and observing necessary safety precautions.

PERFORMANCE MEASURE
M6.6 Demonstration of metal-tempering to specifications provide by the instructor, rated acceptable on instructor-provided checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Determine the area to be tempered.
2. Determine the method to be used.
3. Identify tempering equipment.
4. Identify safety hazards.
5. Identify the color of the metal for the temperature range.

DUTY AREA
6. PROCESSING METALS

COURSE
Precision Machining Technology I (8539)
MAC 146

TASK / COMPETENCY
6.7 Surface-harden metals.

PERFORMANCE OBJECTIVE
P6.7 Given a piece of medium carbon steel, a blueprint, and safety equipment, surface-harden the steel according to blueprint specifications. Demonstration should include setting up the heat medium, determining amount of heat and length time required, and testing for proper surface-hardening.

PERFORMANCE MEASURE
M6.7 Demonstration of surface-hardening to blueprint specifications, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Set up heat medium (acetylene torch or induction heating).
2. Determine amount of heat and length of time required.
3. Test part to determine if surface has been hardened properly.

DUTY AREA 7. OPERATING POWER SAWS

7.1 Select appropriate blades.
7.2 Select and set speeds and feeds for sawing operations.
7.3 Saw to scribed lines, using a metal band saw.
7.4 Measure and cut metal, using a power saw.
7.5 Remove and replace saw blades.
7.6 Cut and weld a band saw blade for contour sawing.

DUTY AREA
7. OPERATING POWER SAWS

COURSE
Precision Machining Technology I (8539)
MAC 107

TASK / COMPETENCY
7.1 Select appropriate blades.

PERFORMANCE OBJECTIVE
P7.1 Given a workpiece, job specifications, a *Machinist's Handbook*, and saw blades, select appropriate blades for sawing operations. Demonstration must include identification of metal and determination of metal thickness.

PERFORMANCE MEASURE
M7.1 Demonstration, all items on instructor-prepared checklist rated acceptable

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain pitch, set, thickness, width, composition, and kerf.
2. Measure the metal thickness.
3. Identify ferrous and nonferrous metals.
4. Discuss AA (Aluminum Association) identification of aluminum.

DUTY AREA
7. OPERATING POWER SAWS

COURSE
Precision Machining Technology I (8539)
MAC 107

TASK / COMPETENCY
7.2 Select and set speeds and feeds for sawing operations.

PERFORMANCE OBJECTIVE
P7.2 Given access to a power saw, job specifications, description of the workpiece, a manufacturer's operational manual, and a *Machinist's Handbook*, select and set speeds and feeds for sawing operations according to instructor-provided standards. Demonstration should include identifying machine controls and parts and observing necessary safety precautions.

PERFORMANCE MEASURE
M7.2 Demonstration, all items on instructor-prepared checklist rated acceptable

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify machine controls and parts.
2. Select the speed and feed for the metal to be cut.
3. Set up and use the feed and speed.
4. Perform the proper setup for various shaped metals.
5. Demonstrate safety practices in using the saw.

DUTY AREA
7. OPERATING POWER SAWS

COURSE
Precision Machining Technology I (8539)
MAC 106, 206

TASK / COMPETENCY
7.3 Saw to scribed lines, using a metal band saw.

PERFORMANCE OBJECTIVE
P7.3 Given job specifications and a workpiece, saw to scribed lines, using a metal band saw. Demonstration must include determining the dimensions to be cut, measuring and scribing the dimensions on the workpiece, and observing necessary safety practices.

PERFORMANCE MEASURE
M7.3 Demonstration, all items on instructor-prepared checklist rated acceptable

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Determine the dimensions to be cut.
2. Measure and scribe the dimensions on the workpiece.
3. Demonstrate machine setup and operation.
4. Demonstrate safety practices in using the band saw.

DUTY AREA
7. OPERATING POWER SAWS

COURSE
Precision Machining Technology I (8539)
MAC 146

TASK / COMPETENCY
7.4 Measure and cut metal, using a power saw.

PERFORMANCE OBJECTIVE
P7.4 Given job specifications, workpiece, steel rule, file, scribe, saw vice, and floor stand, measure and cut metal, using a power saw, to ±1/16" accuracy. Demonstration must be performed in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M7.4 Demonstration, accurate within ±1/16" and all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify the controls of the power saw.
2. Identify the holding devices.
3. Demonstrate safe work habits in using the power saw.
4. Demonstrate wet and dry types of cutting operations.
5. Identify holding positions for the materials to be cut.

DUTY AREA
7. OPERATING POWER SAWS

COURSE
Precision Machining Technology I (8539)
MAC 151

TASK / COMPETENCY
7.5 Remove and replace saw blades.

PERFORMANCE OBJECTIVE
P7.5 Given a metal band saw, blades, hand tools, and a reference handbook, remove and replace saw blades according to specifications in the handbook. Demonstration must be performed in accordance with instructor's guidelines, including all necessary safety procedures.

PERFORMANCE MEASURE
M7.5. Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Inspect the blades for serviceability.
2. Demonstrate safety procedures during the removal of old blades and the installation of new ones.
3. Identify the types of blades and their characteristics.
4. Demonstrate the proper procedures for installing the blades on both the power hacksaw and the band saw.

DUTY AREA
7. OPERATING POWER SAWS

COURSE
Precision Machining Technology I (8539)

TASK / COMPETENCY
7.6 Cut and weld a band saw blade for contour sawing.

PERFORMANCE OBJECTIVE
P7.6 Given a textbook reference, a drilled workpiece, and a band saw with a butt welder and grinder, cut and weld a band saw blade for contour sawing. The workpiece, the rewelded blade, and the band saw operational procedure must meet textbook specifications. Demonstration should include removing the blade tension, cutting the blade, butt welding, grinding, annealing the weld, and reinstalling the blade.

PERFORMANCE MEASURE
M7.6 Demonstration, all items on instructor-prepared checklist rated acceptable

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain the procedure for removing the blade tension.
2. Demonstrate the techniques for cutting the band saw blade.
3. Demonstrate how to insert the blade through the workpiece.
4. Demonstrate butt welding, grinding, and annealing the weld.
5. Reinstall the blade on the band saw rotating wheels.
6. Demonstrate the procedure for making a contour cut with the band saw.
7. Restore the saw to its normal operation.

DUTY AREA 8. OPERATING DRILLING MACHINES

8.1 Identify the characteristics of the material to be drilled.
8.2 Determine holding techniques.
8.3 Select a tool or cutter for the drill press operation.
8.4 Secure the tools or cutters in the drill press spindle.
8.5 Select a sleeve to suit the drill.
8.6 Set the drillpress feeds and speeds.
8.7 Drill a hole to size.
8.8 Sharpen the drill bit by hand and by using drill sharpener.
8.9 Use a tapping attachment to tap a hole.
8.10 Hand-tap a hole.

DUTY AREA
8. OPERATING DRILLING MACHINES

COURSE
Precision Machining Technology I (8539)
MAC 107, 146

TASK / COMPETENCY
8.1 Identify the characteristics of the material to be drilled.

PERFORMANCE OBJECTIVE
P8.1 Given materials to be drilled, a blueprint and a *Machinist's Handbook*, identify the characteristics of the material to be drilled according to table specifications in the *Machinist's Handbook*, or by using cutting, filing, drilling, and general machining procedures. Identification must be within instructor-specified degree of accuracy.

PERFORMANCE MEASURE
M8.1 Instructor-prepared test, completed within instructor-specified degree of accuracy and rated acceptable based on instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate the testing of materials, using filing, cutting, drilling, and general machining techniques.
2. Identify the characteristics of materials, using cutting, drilling, and general machining procedures.
3. Identify the characteristics of materials, using the tables in the *Machinist's Handbook*.

DUTY AREA
8. OPERATING DRILLING MACHINES

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
8.2 Determine holding techniques.

PERFORMANCE OBJECTIVE
P8.2 Given job specifications and an assortment of holding devices and materials, determine holding techniques, including use of drill press vise, wood or parallel bars, and special holding devices, jigs, and fixtures, according to instructor's guidelines.

PERFORMANCE MEASURE
M8.2 Instructor-prepared checklist, all items rated acceptable

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate the use of holding devices for the drill press, with an emphasis on the drill press vise and wood or parallel bars.
2. Explain the special holding devices, jigs, and fixtures used for drill press operations.
3. Identify safety rules.

DUTY AREA
8. OPERATING DRILLING MACHINES

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
8.3 Select a tool or cutter for the drill press operation.

PERFORMANCE OBJECTIVE
P8.3 Given a blueprint, an assortment of straight-shank and taper-shank tools or cutters (e.g., counterbore, countersink, drill, reamer, and spot facing tool), select a tool or cutter for the drill press operation according to blueprint specifications. Demonstration must be performed in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M8.3 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate the techniques necessary for preparing projects for precision drilling.
2. Select hand tools and layout instruments for metal trade proficiencies.
3. Demonstrate blueprint reading.
4. Identify the holding devices that secure the tool or cutter and those that secure the workpiece.
5. Demonstrate the setups and adjustments that may be required.
6. Identify safety practices in mounting workpieces in the drill press.
7. Identify other types of cutters used on the drill press, e.g., countersink, counterbore, and reamer.

DUTY AREA
8. OPERATING DRILLING MACHINES

COURSE
Precision Machining Technology I (8539)

TASK / COMPETENCY
8.4 Secure the tools or cutters in the drill press spindle.

PERFORMANCE OBJECTIVE
P8.4 Given a drill press, a manufacturer's manual, and an assortment of straight-shank and taper-shank tools or cutters (e.g., counterbore, countersink, drill, reamer, spot facing tool, chuck and key, mallet, and drift for taper-shank tool or cutter), secure the tools or cutters in the drill press spindle according to the specifications in the manufacturer's manual. Demonstration must include one straight and one taper shank tool or cutter.

PERFORMANCE MEASURE
M8.4 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Determine the size and type of spindle taper and straight-shank holders by the following procedures:
   a. cleaning the shank of the chuck
   b. aligning the tang of the chuck into the drill press spindle
   c. securing the chuck into the drill press spindle
   d. securing the tool/cutter into the chuck
   e. inserting the drift and removing the chuck.
2. Clean the shank of the tool/cutter and secure the tool/cutter into the drill press spindle by
   a. aligning the tang
   b. selecting the appropriate sleeve
   c. snugging the tool/cutter.
3. Determine the amount of "run-out" if the drill is not true.
4. Identify safety rules.

DUTY AREA
8. OPERATING DRILLING MACHINES

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
8.5 Select a sleeve to suit the drill.

PERFORMANCE OBJECTIVE
P8.5 Given a *Machinist's Handbook*, drill, an assortment of sleeves or steel sockets, precision measurement instruments, and a machinist's rule, select a sleeve to suit the drill, according to table specifications. Demonstration must include drilling operations that require sleeving and drill chuck changes in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M8.5 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain drill press safety and personal equipment care.
2. Demonstrate drilling large holes, drilling holes in round stock, and other drilling operations that require sleeving and drill chuck changes.

DUTY AREA
8. OPERATING DRILLING MACHINES

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
8.6 Set the drill press feeds and speeds.

PERFORMANCE OBJECTIVE
P8.6 Given a drill press, blueprint, and a manufacturer's operational manual, set the drill press feeds and speeds. Instructor's guidelines must be followed and all safety precautions observed.

PERFORMANCE MEASURE
M8.6 Demonstration, performed with 100% accuracy

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Determine the necessary speeds and feeds.
2. Determine the results of excessive feeds and speeds and break-through lunger.
3. Adjust the spindle speed.

DUTY AREA
8. OPERATING DRILLING MACHINES

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
8.7 Drill a hole to size.

PERFORMANCE OBJECTIVE
P8.7 Given a blueprint, workpiece, drill press, lubricant, work-holding devices, drills, combination drill and countersink, and deburring tool, drill a hole to size with an accuracy of ±0.005" (nominal drill diameter in inches is ±0.003"). Demonstration should include all procedures for safe drilling, as outlined in instructor's guidelines.

PERFORMANCE MEASURE
M8.7 Demonstration, hole drilled to an accuracy of ±0.005" and all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Make a safety test on drill press and drilling operations.
2. Identify the workpiece material.
3. Select a holding device and accessories.
4. Secure workpiece in the holding device and check the setup for rigidity.
5. Use a center punch and proof punch.
6. Align the workpiece and center the drill.
7. Select and mount the drill.
8. Determine the kind and amount of lubricant/coolant to use.
9. Drill to the dimensions and lubricate, if necessary.
10. Deburr the hole.
11. Ream the hole to size.
12. Spotface the workpiece.
13. Countersink a hole to drawing requirements.
14. Drill and counterbore a hole.

DUTY AREA
8. OPERATING DRILLING MACHINES

COURSE
Precision Machining Technology I (8539)
MAC 106

TASK / COMPETENCY
8.8 Sharpen the drill bit by hand and by using drill sharpener.

PERFORMANCE OBJECTIVE
P8.8 Given a grinder, wheel dresser, drills, sharpening specifications, and a protractor or drill point gauge, sharpen the drill bit by hand and by using drill sharpener, according to the sharpening specifications. Demonstration must include dressing and truing the grinding wheel and be performed in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M8.8 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Describe the safety hazards involved in sharpening drill bits by hand.
2. Dress and true the grinding wheel.
3. Grind the lip clearance, length, and angle to the specifications.
4. Check for sharpness.

DUTY AREA
8. OPERATING DRILLING MACHINES

COURSE
Precision Machining Technology I (8539)
MAC 206

TASK / COMPETENCY
8.9 Use a tapping attachment to tap a hole.

PERFORMANCE OBJECTIVE
P8.9 Given a drill press, a blueprint, *Machinist's Handbook*, workpiece, work-holding device, go-no-go gauges, tap drill, tapping attachment, drill chuck and key, and cutting oil, use a tapping attachment to tap a hole according to blueprint specifications. Demonstration must include all procedures for safe tapping as outlined in instructor's guidelines.

PERFORMANCE MEASURE
M8.9 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Select the tap drill and tap.
2. Secure the workpiece to the drill press table.
3. Set the speed and feed.
4. Center-punch and drill the hole.
5. Mount and secure the tapping attachment and tap.
6. Lubricate and tap the hole to the specifications.
7. Identify taps (starter, plug, bottoming).
8. Identify types of taps (gun, standard, spiral, machine hogging).
9. List considerations necessary for "blind holes" (chips, etc.).
10. Explain the safety hazards involved in using a tapping attachment.

DUTY AREA
8. OPERATING DRILLING MACHINES

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
8.10 Hand-tap a hole.

PERFORMANCE OBJECTIVE
P8.10 Given a drill press, a blueprint, a workpiece, a *Machinist's Handbook*, tap drills, tap wrench, taps, drill chuck and key, drill press vise, straps and bolts, combination drill and countersink, dead center, lubricant, and appropriate measurement instruments, hand-tap a hole to the blueprint specifications. Demonstration must include all proper procedures for safe hand-tapping as outlined in instructor's guidelines.

PERFORMANCE MEASURE
M8.10 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Select the tap drill and tap as specified on the blueprint.
2. Mount and secure the workpiece to the drill table vise.
3. Select and set the drill press speed.
4. Drill the workpiece to the thread size specifications.
5. Mount and tap in the tap wrench, and align it to the drilled hole.
6. Mount the dead center in the drill chuck, and align it to the tap wrench.
7. Identify taps (starter, plug, bottoming).
8. Identify types of taps (gun, standard, spiral, machine hogging).
9. List the considerations necessary for "blind holes" (chips, etc.).

DUTY AREA 9. OPERATING ABRASIVE MACHINES

9.1 Install the grinding wheel.
9.2 Dress and true the grinding wheel.
9.3 Balance the grinding wheel.
9.4 Select appropriate attachments and grind workpiece.
9.5 Set up the grinder to run the workpiece on a magnetic chuck.
9.6 Perform surface-grinding operations.
9.7 Measure, inspect, and rework the workpiece on the grinding machine.
9.8 Shape chisel on the pedestal grinder.
9.9 Grind and sharpen a preshaped lathe tool.
9.10 Perform belt- and disk-grinding operations.
9.11 Perform honing operations.

DUTY AREA
9. OPERATING ABRASIVE MACHINES

COURSE
Precision Machining Technology II (8540)
MAC 205

TASK / COMPETENCY
9.1 Install the grinding wheel.

PERFORMANCE OBJECTIVE
P9.1 Given the manufacturer's specifications, access to a grinding wheel, and grinding machine attachments, install the grinding wheel according to the manufacturer's specifications.

PERFORMANCE MEASURE
M9.1 Demonstration, performed with 100% accuracy according to manufacturer's specifications

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Determine the grinding wheel specifications.
2. Select the proper grinding wheel.

DUTY AREA
9. OPERATING ABRASIVE MACHINES

COURSE
Precision Machining Technology II (8540)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
9.2 Dress and true the grinding wheel.

PERFORMANCE OBJECTIVE
P9.2 Given a reference book, access to a grinder, grinding wheel, diamond point dresser, and fixed tool post, dress and true the grinding wheel according to the reference specifications.

PERFORMANCE MEASURE
M9.2 Demonstration, performed with 100% accuracy according to reference book specifications

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate the use of the diamond point dresser.
2. Determine the material to be removed from the grinding wheel.
3. Perform a pre-operational check on the grinder.
4. Determine the reference specifications for dressing and truing the grinding wheel.
5. Practice dressing and truing the wheel.

DUTY AREA
9. OPERATING ABRASIVE MACHINES

COURSE
Precision Machining Technology II (8540)
MAC 205

TASK / COMPETENCY
9.3 Balance the grinding wheel.

PERFORMANCE OBJECTIVE
P9.3 Given access to a grinding wheel, wheel mount, balance stand, manufacturer's specifications, and weights, balance the grinding wheel according to the manufacturer's specifications.

PERFORMANCE MEASURE
M9.3 Demonstration, rated acceptable on instructor-prepared checklist based on manufacturer's specifications

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate how to use a balance stand, wheel mount, and weights to balance the wheel.
2. Demonstrate using a drill bit to remove excess material in order to balance the grinding wheel.
3. Remount the hub or wheel mount on the grinder.

DUTY AREA
9. OPERATING ABRASIVE MACHINES

COURSE
Precision Machining Technology II (8540)
MAC 106, 205, 206

TASK / COMPETENCY
9.4 Select appropriate attachments and grind workpiece.

PERFORMANCE OBJECTIVE
P9.4 Given a blueprint, workpiece, access to a utility grinder, table of abrasives, an assortment of abrasives, and grinding attachments, select appropriate attachments and grind workpiece to blueprint specifications.

PERFORMANCE MEASURE
M9.4 Demonstration, rated acceptable on instructor-prepared checklist based on blueprint specifications

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Perform pre-operational inspections and tests.
2. Select abrasives for the given workpiece and wheel specifications.
3. Identify and select grinding attachments.
4. Secure the workpiece in the holding device and mark for grinding according to specifications.
5. Practice grinding the workpiece to specifications.

DUTY AREA
9. OPERATING ABRASIVE MACHINES

COURSE
Precision Machining Technology II (8540)
MAC 106, 205, 206

TASK / COMPETENCY
9.5 Set up the grinder to run the workpiece on a magnetic chuck.

PERFORMANCE OBJECTIVE
P9.5 Given access to a grinder, a *Machinist's Handbook*, magnetic chuck, workpiece, cleaner, hones, grinding wheel, diamond point dresser, blocks, parallels, V-blocks, magnavise clamps, coolants, squeegee, and rags, set up the grinder to run the workpiece on a magnetic chuck. Demonstration should be performed in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M9.5 Instructor-prepared checklist, all procedures rated acceptable

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate the procedure for cleaning and checking the magnetic chuck.
2. Identify the magnetic chuck controls and limits.
3. Demonstrate the use of magnetic clamps.

DUTY AREA
9. OPERATING ABRASIVE MACHINES

COURSE
Precision Machining Technology II (8540)
MAC 106, 205, 206

TASK / COMPETENCY
9.6 Perform surface-grinding operations.

PERFORMANCE OBJECTIVE
P9.6 Given a blueprint, access to a grinder, grinder accessories, precision measurement instruments, and a workpiece, perform surface-grinding operations to an accuracy of ±0.001". Demonstration should include all procedures for safe surface grinding as outlined in instructor's guidelines.

PERFORMANCE MEASURE
M9.6 Demonstration of surface grinding, accurate to within ±0.001" and all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate how to select and secure the work-holding device.
2. Demonstrate how to select, check, and mount the grinding wheel.
3. Demonstrate how to true and dress the wheel.
4. Demonstrate how to select and set up speeds and feeds.
5. Identify the proper coolant.
6. Demonstrate how to secure and align the workpiece.
7. Practice setting up the grinder and performing surface-grinding operations to a specified accuracy.

DUTY AREA
9. OPERATING ABRASIVE MACHINES

COURSE
Precision Machining Technology II (8540)
MAC 106, 205, 206

TASK / COMPETENCY
9.7 Measure, inspect, and rework the workpiece on the grinding machine.

PERFORMANCE OBJECTIVE
P9.7 Given a blueprint, heat-treated workpiece, access to a grinder, accessories, and precision measurement instrument, inspect, measure, and rework the workpiece on the grinding machine to a finished accuracy of ±0.001". Demonstration should be performed in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M9.7 Demonstration, accurate within ±0.001" and all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Check the blueprint against the workpiece.
2. Demonstrate the use of precision measurement instruments to measure the workpiece.
3. Inspect the workpiece for flaws.
4. Practice reworking the workpiece to a specified accuracy.

DUTY AREA
9. OPERATING ABRASIVE MACHINES

COURSE
Precision Machining Technology I (8539)
MAC 146

TASK / COMPETENCY
9.8 Shape chisel on the pedestal grinder.

PERFORMANCE OBJECTIVE
P9.8 Given access to a pedestal grinder, wheel dresser, chisel, machinist's square, and bevel protractor, shape chisel on the pedestal grinder to an included angle of 60°-70°. Demonstration should be performed in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M9.8 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Inspect the grinding wheel.
2. Dress and true the grinding wheel.
3. Set the protractor to the desired angle.
4. Set the workpiece to get a cut of 60°, using a bevel protractor.
5. Practice shaping chisel to get the specified cut.

DUTY AREA
9. OPERATING ABRASIVE MACHINES

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
9.9 Grind and sharpen a preshaped lathe tool.

PERFORMANCE OBJECTIVE
P9.9 Given a blueprint, reference book, access to tool grinder, diamond point dresser, preshaped lathe tool, clearance and cutting-angle gauge, and bevel protractor, grind and sharpen a preshaped lathe tool to the blueprint specifications. The lathe tool contour must meet the requirements in the reference book table, angular dimensions must be accurate within ±1/2°, and demonstration must be performed in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M9.9 Demonstration, angular dimensions accurate within ±1/2° and all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Set up the grinder to cut preshaped lathe tools.
2. Determine lathe tool contour from reference book table.
3. Set the proper clearance and dimension.
4. Practice grinding and sharpening the tool to a specified accuracy.

DUTY AREA
9. OPERATING ABRASIVE MACHINES

COURSE
Precision Machining Technology II (8540)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
9.10 Perform belt- and disk-grinding operations.

PERFORMANCE OBJECTIVE
P9.10 Given specifications and access to a belt and disk grinder, perform belt- and disk-grinding operations according to instructor's specifications.

PERFORMANCE MEASURE
M9.10 Demonstration, grinding operations performed with 100% accuracy according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Determine the belt and/or disk specifications (size, grit, bond, etc.) from the reference book.
2. Select the appropriate belt and/or disk.
3. Select the appropriate holding procedure.
4. Adjust guards, belt, and work tables.
5. Practice belt- and disk-grinding to a specified accuracy.

DUTY AREA
9. OPERATING ABRASIVE MACHINES

COURSE
Precision Machining Technology II (8540)
MAC 107

TASK / COMPETENCY
9.11 Perform honing operations.

PERFORMANCE OBJECTIVE
P9.11 Given the manufacturer's specifications, access to a honing machine, and honing machine attachments, perform honing operations within ±0.001" accuracy according to manufacturer's and instructor's specifications.

PERFORMANCE MEASURE
M9.11 Demonstration, accurate within ±0.001" and all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Select appropriate honing stones according to reference book specifications.
2. Select appropriate measuring tools to perform honing operations.
3. Select appropriate lubricant.
4. Determine the proper holding procedure (hand or attachments).
5. Practice honing operations.

DUTY AREA 10. OPERATING LATHES

10.1 Select and set speeds and feeds.
10.2 Set up tool holders, fixtures, and attachments.
10.3 Rough-cut and finish-cut, using a lathe.
10.4 Perform lathe filing.
10.5 Knurl parts, using a lathe.
10.6 Cut off the workpiece, using a lathe.
10.7 Align lathe centers, using precision measurement.
10.8 Drill holes, using a lathe.
10.9 Countersink holes, using a lathe.
10.10 Ream holes, using a lathe.
10.11 Tap threads, using a lathe.
10.12 Die-cut threads, using a lathe (hand-threading).
10.13 Cut short, externally tapered surfaces.
10.14 Perform contour, angular, and radial cuts, using a lathe.
10.15 Cut external threads, using a lathe.
10.16 Rechase threads, using a lathe.
10.17 Cut long, externally tapered surfaces, using a taper attachment.
10.18 Bore holes, using a lathe.
10.19 Counterbore holes, using a lathe.
10.20 Cut internal threads, using a lathe.
10.21 Cut internally tapered surfaces.
10.22 Die-cut threads with a lathe, using die heads.
10.23 Set up the tool post grinder.
10.24 Use the tool post grinder.

RELATED ACADEMIC STANDARDS OF LEARNING
(Based on 1995 SOLs)

MATH		TECHNICAL COMPETENCY
T.9	The student will identify, create, and solve practical problems involving triangles and vectors. Techniques will include using the trigonometric functions, the Pythagorean Theorem, the Law of Sines, and the Law of Cosines.	10.7

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
10.1 Select and set speeds and feeds.

PERFORMANCE OBJECTIVE
P10.1 Given a blueprint, workpiece, access to a lathe and accessories, manufacturer's operational manual, and a *Machinist's Handbook*, select and set speeds and feeds to perform machining operations specified on the blueprint according to the appropriate table in the *Machinist's Handbook*. Demonstration should include identification of the characteristics of various types of cutting tools and cutting oils and performance of calculations using the formula given below.

PERFORMANCE MEASURE
M10.1 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify various types of cutting tools and their characteristics in regard to type of cutting action, depth of cuts, feed rates, speeds, tool life, and material.
2. Identify various types of cutting oils and their influence on different metals and cutting tools.
3. Select speeds and feeds based on tables in the *Machinist's Handbook*.
4. Identify and define the parts of the lathe that govern speeds and feeds.
5. Define the relationship between the speed and the depth of cut and finish.
6. Perform calculations, using the formula: $PM = \frac{CS \times 12}{\pi \times D}$

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
10.2 Set up tool holders, fixtures, and attachments.

PERFORMANCE OBJECTIVE
P10.2 Given a blueprint, workpiece, access to a lathe, and accessories, set up tool holders, fixtures, and attachments to perform the machine operations specified on the blueprint. Demonstration should include use of basic handtools needed for securing attachments and identification of lathe tool angles and their correct position in relation to the workpiece.

PERFORMANCE MEASURE
M10.2 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Interpret a blueprint or a shop sketch.
2. Identify the major parts of the lathe, and define their functions.
3. Identify the accessories, tool holders, fixtures, and attachments, and define their functions.
4. Explain the various lathe operations.
5. Demonstrate the basic hand tools needed for securing the attachments.
6. Identify the lathe tool angles and their correct position in relation to the workpiece.
7. Identify the various shapes of a workpiece.

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
10.3 Rough-cut and finish-cut, using a lathe.

PERFORMANCE OBJECTIVE
P10.3 Given a properly mounted workpiece, blueprint, access to a lathe and accessories, cutting tool, and precision measurement instruments, rough cut the workpiece to an accuracy of ±0.007" and finish-cut the workpiece to an accuracy of ±0.002", using a lathe. Demonstration should include all procedures for setting up and using the lathe as outlined in instructor's guidelines.

PERFORMANCE MEASURE
M10.3 Demonstration, accurate within ±0.007" for rough cut and within ±0.002" for finish cut and all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Align the lathe centers, using the approximate method.
2. Select and set speeds and feeds.
3. Set up tool holders, fixtures, and attachments.
4. Set up the lathe and face the workpiece held in a chuck.
5. Perform lathe filing to deburr part.
6. Identify the types of finishes and explain their relationship to tool geometry and feed rates.

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology I (8539)
MAC 106

TASK / COMPETENCY
10.4 Perform lathe filing.

PERFORMANCE OBJECTIVE
P10.4 Given a blueprint, workpiece, access to a lathe and accessories, files, file handles, file card, brush, lubricant, and micrometer caliper, perform lathe filing, leaving 0.001" or other blueprint-specified amount for polishing.

PERFORMANCE MEASURE
M10.4 Demonstration, blueprint-specified amount left for polishing and all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Select and set speeds.
2. Perform lathe filing to deburr the workpiece.
3. File the workpiece to the specification.
4. Identify safety procedures.

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology I (8539)
MAC 106, 107

TASK / COMPETENCY
10.5 Knurl parts, using a lathe.

PERFORMANCE OBJECTIVE
P10.5 Given a properly mounted workpiece, blueprint, access to a lathe and accessories, knurling tool, tool holder, scribe, brush, cutting oil, and precision measurement instruments, knurl parts, using a lathe, to the size specified on the blueprint. Allow for an increase of 0.002" to 0.004" of the original diameter. Demonstration should include all procedures for setting up and using the lathe as outlined in instructor's guidelines.

PERFORMANCE MEASURE
M10.5 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Define and select various types and grades of knurls.
2. Select and set speeds and feeds.
3. Set up tool holders, fixtures, and attachments.
4. Set up the lathe and face the workpiece held in a chuck.
5. Perform lathe filing to deburr part.
6. Rough-cut and finish-cut with a lathe.
7. Perform lathe filing.
8. Define and list the methods used to correct for push-off.

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology I (8539)
MAC 106,107

TASK / COMPETENCY
10.6 Cut off the workpiece, using a lathe.

PERFORMANCE OBJECTIVE
P10.6 Given a blueprint, workpiece, access to a lathe, parting tool, lubricant, and precision measurement instruments, cut off the workpiece, using a lathe, to blueprint specifications. Demonstration should include all procedures for setting up and using the lathe safely as outlined in instructor's guidelines.

PERFORMANCE MEASURE
M10.6 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Select and set speeds and feeds.
2. Set up tool holders, fixtures, and attachments.
3. Set up the lathe and face the workpiece held in a chuck.
4. Identify the clearance and the cutting edge angles on a cut-off tool.
5. Calculate speed and feed for parting operations.
6. Define *deflection, push-off,* and *spring* in regard to cutting operations.
7. Identify safety practices in parting-off operations.

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology II (8540)
MAC 107, 205

TASK / COMPETENCY
10.7 Align lathe centers, using precision measurement.

PERFORMANCE OBJECTIVE
P10.7 Given two dead centers, spindle adaptor, drill rod test bar, dial indicator, and lathe wrenches, align lathe centers to a tolerance of 0.001" TIR, using precision measurement. Demonstration should include using the appropriate method as well as the precision dial indicator according to instructor's guidelines.

PERFORMANCE MEASURE
M10.7 Demonstration, lathe centers aligned to a tolerance of 0.001" TIR and all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Align lathe centers, using the approximate method.
2. Set up and use the precision dial indicator to align both ends of the lathe.

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
10.8 Drill holes, using a lathe.

PERFORMANCE OBJECTIVE
P10.8 Given a blueprint, workpiece, access to a lathe and accessories, cutting tool, combination drill and countersink, drills, lubricant, and precision measurement instruments, drill holes, using a lathe, to blueprint specifications. Demonstration should include determining types of drills and drill holders, proper cutting action, drill geometry, and feed rate according to instructor's guidelines.

PERFORMANCE MEASURE
M10.8 Demonstration, holes drilled to an accuracy of $\pm$0.005" for drills of 1/8" to 1" diameter and all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Determine the types of drills (sizes, shanks, styles).
2. Determine the types of drill holders (drill chuck, sleeves, etc.).
3. Determine sizes, types, and speeds for combination countersinks and counter drills.
4. Perform the inside measurements to the accuracy specified.
5. Determine the proper cutting action for a drill (chip, color, shape, and flute discharge load).
6. Determine the proper drill geometry (lip length, clearance angle, drill point angle, chisel point angle).
7. Determine the proper feed rate by turning the tailstock handle.

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
10.9 Countersink holes, using a lathe.

PERFORMANCE OBJECTIVE
P10.9 Given a blueprint, workpiece, lathe attachments, combination drill and countersink, drills, lathe center bit, and countersink cutter, countersink holes, using a lathe, to blueprint specifications. Demonstration should include identification of the reference axis of an angle given in the blueprint and the countersink on the blueprint, and use of the tool axis and various countersink tools and their angles, according to instructor's guidelines.

PERFORMANCE MEASURE
M10.9 Demonstration, holes countersunk to blueprint specifications and all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify angles.
2. Identify the reference axis of an angle given in the blueprint.
3. Identify and use the tool axis from the compound of the lathe.
4. Identify the countersink on a blueprint, and determine the location of the dimensions given.
5. Identify and use the various countersink tools and their angles.

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
10.10 Ream holes, using a lathe.

PERFORMANCE OBJECTIVE
P10.10 Given a blueprint, workpiece, access to a lathe and attachments, cutting tool, combination drill and countersink, drills, boring bar, reamers and holder, inside caliper, plug gauge, and micrometer caliper, ream holes, using a lathe, to a tolerance of ±0.005". Demonstration should include identification of types of reamers and holders, calculation of speeds and feeds, performance of measurements with gauges and calipers, and identification of advantages and disadvantages of various reamers, according to instructor's guidelines.

PERFORMANCE MEASURE
M10.10 Demonstration, holes reamed to a tolerance of ±0.005" and all steps rated acceptable on instructor-prepared checklist.

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify the types of reamers by style and shape of shank end (hand or machine).
2. Identify the type of holder for various reamers.
3. Calculate speeds and feeds for reaming operations.
4. Perform measurements with inside calipers, plug gauges, and micrometer calipers.
5. State the advantages and disadvantages of various reamers with regard to their shape or flute design.
6. Identify the cutting area and length of cutting area for the various reamers.

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology I (8539)
MAC 107, 205, 206

TASK / COMPETENCY
10.11 Tap threads, using a lathe.

PERFORMANCE OBJECTIVE
P10.11 Given a blueprint, workpiece, access to a lathe and accessories, cutting tool, lubricant, combination drill and countersink, drills and drill chuck, hand taps, tap wrench, and go-no-go and plug gauges, tap threads, using a lathe, to blueprint specifications. Demonstration should include identification of various types of taps, tap wrenches, and thread forms, and use of go-no-go and plug gauges, according to instructor's guidelines.

PERFORMANCE MEASURE
M10.11 Demonstration, threads tapped to tolerance specified in blueprint and all steps rated acceptable on instructor-prepared checklist.

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Select the proper tap drill size on the basis of fit and percentage of full thread.
2. Identify the basic parts of thread: major/minor, pitch, etc.
3. Define drunken threads, stripped threads, and classification of fit.
4. Identify the thread designation in the blueprint.
5. Identify the various types of taps and explain their use.
6. Identify the various types of tap wrenches (e.g., t-handle, straight, free, floating).
7. Identify various types of thread forms (e.g., un, acme, NTPT, N.D., N.F., etc.).
8. Demonstrate the proper use and fit of go-no-go gauges and plug gauges.
9. Differentiate between cutting oil, lubricant, coolant, and thread-cutting fluid.

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology I (8539)
MAC 107

TASK / COMPETENCY
10.12. Die-cut threads, using a lathe (hand-threading).

PERFORMANCE OBJECTIVE
P10.12 Given a blueprint, round stock, access to a lathe and accessories, dies, die stock, cutting oil, releasing-type die holder, ring, thread gauge, and nut, die-cut threads, using a lathe (hand-threading). External threads on round stock must meet the blueprint specifications as determined by using a thread gauge and nut. Demonstration should include identification of various types of dies, basic types of die-holding devices, and the pitch diameter, and use of ring gauges, according to instructor's guidelines.

PERFORMANCE MEASURE
M10.12 Demonstration, threads die-cut to blueprint specifications and all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify the pitch diameter and explain its significance.
2. Demonstrate the use of ring gauges.
3. Identify the basic types of die-holding devices.
4. Identify the front and back of the die.
5. Demonstrate the proper method of adjusting split dies.
6. Identify the various types of dies and describe their uses.

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology I (8539)
MAC 106,107

TASK / COMPETENCY
10.13 Cut short, externally tapered surfaces.

PERFORMANCE OBJECTIVE
P10.13 Given a blueprint, workpiece, access to lathe and accessories, combination drill and countersink, taper gauge, cutting tool, and precision measurement instruments, cut short, externally tapered surfaces to blueprint specifications. Demonstration should include adjustment of the compound rest, calculation of amounts, rates, and angles of taper, and identification of the reference axis of the angle given in the blueprint, according to instructor's guidelines.

PERFORMANCE MEASURE
M10.13 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify and demonstrate the use of a taper gauge.
2. Calculate the amounts of taper, rates of taper (per inch and per foot), and angles of taper.
3. Identify angles.
4. Identify the reference axis of the angle given in the blueprint.
5. Identify the tool axis and the compound rest.

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
10.14 Perform contour, angular, and radial cuts, using a lathe.

PERFORMANCE OBJECTIVE
P10.14 Given a blueprint, workpiece, lathe and accessories, cutting tool, vernier bevel protractor, radius gauge, hermaphrodite caliper, micrometer caliper, and steel rule, perform contour, angular, and radial cuts, using a lathe, according to the blueprint specifications. The length must be accurate within $\pm$1/64", the diameter must meet the blueprint specifications, and the angular cuts must be accurate within $\pm$ 1/2°. Demonstration should include use of the tools listed above, calculation of radial measurements, and grinding contour and radius tools, according to instructor's guidelines.

PERFORMANCE MEASURE
M10.14 Demonstration, cuts made to tolerances specified above and all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify and perform measurements with a vernier bevel protractor.
2. Identify and calculate radial measurement.
3. Define *radius, round, fillets, concave,* and *convex.*
4. Demonstrate the use of hermaphrodite calipers.
5. Perform a setup, using a radius gauge.
6. Grind a contour tool.
7. Grind a radius tool.
8. Select speeds, and make radius and contour cuts.

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 225

TASK / COMPETENCY
10.15 Cut external threads, using a lathe.

PERFORMANCE OBJECTIVE
P10.15 Given a blueprint, access to a lathe, workpiece, centers, cutters, tool holder, single-point threading tool, thread center gauge, lubricant, and precision measurement instruments, cut external threads, using a lathe, to the blueprint specifications. Demonstration should include use of the thread gauge, calculation of the major and minor pilot lead, flats, and fits, measurement with the thread micrometer, and setup of lathe for right-hand and left-hand threads, according to instructor's guidelines.

PERFORMANCE MEASURE
M10.15 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify and demonstrate the use of the thread gauge.
2. Grind the thread tools to the proper thread angles and flats.
3. Identify the parts of the lathe concerned with the thread-cutting lead, thread angle, and chasing dial.
4. Identify the basic parts of a thread.
5. Calculate the major and minor pilot lead, flats, and fits.
6. Identify the various thread angles.
7. Perform measurements with the thread micrometers.
8. Explain the difference between right-hand and left-hand threads.
9. Demonstrate the lathe setup for right-hand and left-hand threads.

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology I (8539)
MAC 205

TASK / COMPETENCY
10.16 Rechase threads, using a lathe.

PERFORMANCE OBJECTIVE
P10.16 Given a blueprint, threaded workpiece, access to a lathe and attachments, single-point tool, thread center gauge, and lubricant, rechase threads, using a lathe, to the blueprint specifications. Demonstration should include use of the thread center gauge and the single-point threading tool according to instructor's guidelines.

PERFORMANCE MEASURE
M10.16 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify and demonstrate the use of the thread center gauge.
2. Identify the parts of the lathe concerned with the thread-cutting lead, thread angle, and chasing dial.
3. Identify the basic parts of a thread.
4. Identify and demonstrate the use of the single-point threading tool.

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology II (8540)
MAC 107, 205

TASK / COMPETENCY
10.17 Cut long, externally tapered surfaces, using a taper attachment.

PERFORMANCE OBJECTIVE
P10.17 Given a blueprint, workpiece, access to a lathe with taper attachment and accessories, precision measurement instruments, combination drill and countersink, and a cutting tool, cut long, externally tapered surfaces, using a taper attachment, to blueprint specifications. Demonstration should include use of the dial indicator and micrometers and calculation of rates of taper and taper angles, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M10.17 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Calculate types of taper and rates of taper in inches per foot and inches per inch.
2. Demonstrate the use of the dial indicator.
3. Calculate taper angles.
4. Demonstrate the use of micrometers on a tapered surface.
5. Identify the basic parts of a taper attachment.

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology I (8539)
MAC 205

TASK / COMPETENCY
10.18 Bore holes, using a lathe.

PERFORMANCE OBJECTIVE
P10.18 Given a blueprint, workpiece, access to lathe and attachments, cutting tool, combination drill and countersink, drills, boring bar, inside calipers, micrometer calipers, and steel rule, bore holes, using a lathe, to blueprint specifications within a depth of ± 1/64" and a diameter of ±0.003". Demonstration should include use of the tools listed above and of lathe attachments for the boring operation in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M10.18 Demonstration, accurate to blueprint specifications within a depth of ±1/64" and a diameter of ±0.003" and all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Grind a rough-boring tool.
2. Grind a finish-boring tool.
3. Demonstrate the proper measurement techniques.
4. Define "push-off" overhang.
5. Identify the lathe attachments and their uses for the boring operations.

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology I (8539)
MAC 107

TASK / COMPETENCY
10.19 Counterbore holes, using a lathe.

PERFORMANCE OBJECTIVE
P10.19 Given a blueprint, faced stock with drilled hole, boring bar, cutting tool, access to a lathe and attachments, and inside precision measurement instruments, counterbore holes, using a lathe to the blueprint specifications. Demonstration should include the use of the micrometer carriage stop and the setup of the dial indicator for longitudinal carriage movement, according to instructor's guidelines.

PERFORMANCE MEASURE
M10.19 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify and demonstrate the use of the micrometer carriage stop.
2. Demonstrate the setup of the dial indicator for longitudinal carriage movement.

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology II (8540)
MAC 225

TASK / COMPETENCY
10.20 Cut internal threads, using a lathe.

PERFORMANCE OBJECTIVE
P10.20 Given a blueprint, internal thread specifications, workpiece, access to a lathe, drill chuck and key, combination drill and countersink, drills, cutting tool, boring bar with turning tool bit, single-point threading tool, thread center gauge, and precision measurement instruments, cut internal threads, using a lathe, to blueprint specifications. Demonstration should include calculation of the minor diameter tap drill size and percent of full thread, determination of fit, and lathe setup for right-hand and left-hand threads, according to instructor's guidelines.

PERFORMANCE MEASURE
M10.20 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Calculate the minor diameter tap drill size and percent of full thread.
2. Determine fit.
3. Grind the internal threading tool.
4. Demonstrate the lathe setup for right-hand and left-hand internal threads.

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology II (8540)
MAC 205

TASK / COMPETENCY
10.21 Cut internally tapered surfaces.

PERFORMANCE OBJECTIVE
P10.21 Given a blueprint, workpiece, access to a lathe, steady rest, dial indicator, drill chuck and key, combination drill and countersink, drills, boring bar holder, boring bar with tool, and lathe taper attachment, cut internally tapered surfaces to blueprint specifications. Demonstration should include identification of a steady rest and a follower rest and the setup of the steady rest, according to instructor's guidelines.

PERFORMANCE MEASURE
M10.21 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Cut external tapers, using tailstock-set-over method.
2. Identify a steady rest and a follower rest.
3. Demonstrate the setup of a steady rest.

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology II (8540)
MAC 206

TASK / COMPETENCY
10.22 Die-cut threads with a lathe, using die heads.

PERFORMANCE OBJECTIVE
P10.22 Given a blueprint, round stock, access to a lathe and accessories, dies, die heads, cutting oil, ring, thread gauge, and nut, die-cut threads with a lathe, using die heads. External threads on round stock must meet the blueprint specifications as determined by using a thread gauge and nut. Demonstration should include mounting dies to the die holder, adjusting a releasing-type die holder, and setting speeds and feeds, according to instructor's guidelines.

PERFORMANCE MEASURE
M10.22 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Describe releasing-type die holders.
2. Demonstrate the method of mounting dies to the die holder.
3. Demonstrate the method of adjusting a releasing-type die holder.
4. Set feed rates for the required pitch (turret lathe).
5. Set the speeds for cutting threads.

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology I (8539)
MAC 151

TASK / COMPETENCY
10.23 Set up the tool post grinder.

PERFORMANCE OBJECTIVE
P10.23 Given access to a lathe and accessories, instructions in setting up the tool post grinder, a tool post grinder, grinding wheel, and diamond point dresser, set up the tool post grinder according to the instructions provided. Demonstration should include selecting, ring-testing, and dressing the grinding wheel, setting speeds of the grinder, and selecting the proper coolant, according to instructor's guidelines.

PERFORMANCE MEASURE
M10.23 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Select the proper grinding wheel according to the material and finish.
2. Ring-test the grinding wheel.
3. Dress and grind the wheel.
4. Demonstrate safe practices for lathe grinding.
5. Set speeds of grinder according to manufacturer's specifications.
6. Set up the lathe grinder.
7. Select the proper coolant for the type of material.
8. Set speeds and feeds for inspection.
9. Set the direction of the spindle rotation.
10. Define the following terms: *handwheel, glazed,* and *spark-out.*
11. Set the depth of cut for the grinder.

DUTY AREA
10. OPERATING LATHES

COURSE
Precision Machining Technology I (8539)
MAC 151

TASK / COMPETENCY
10.24 Use the tool post grinder.

PERFORMANCE OBJECTIVE
P10.24 Given access to a lathe with a properly mounted tool post grinder, workpiece, and precision measurement instruments, use the tool post grinder to grind the workpiece to an accuracy of ±0.005". Demonstration should include selecting the proper coolant for the type of material, setting speeds and feeds, setting spindle rotation direction, and setting depth of cut, according to instructor's guidelines.

PERFORMANCE MEASURE
M10.24 Demonstration, accurate within ±0.005" and all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Perform measurements with micrometers.
2. Select the proper coolant for the type of material.
3. Set speeds and feeds.
4. Set the direction of the spindle rotation.
5. Set the depth of cut for the grinder.

DUTY AREA 11. OPERATING MILLING MACHINES

11.1 Align the milling machine head and fixtures.
11.2 Mount and align milling machine attachments.
11.3 Select and set speeds and feeds for milling work.
11.4 Perform end milling.
11.5 Perform flycutting operations.
11.6 Drill holes, using a milling machine.
11.7 Mill an angle.
11.8 Mill arcs.
11.9 Perform reaming operations.
11.10 Cut external keyways.
11.11 Bore holes, using a milling machine.
11.12 Perform form milling.
11.13 Perform indexing operations.
11.14 Mill gears.
11.15 Perform straddle-milling operations on the horizontal mill.
11.16 Mill internal slots, using a slotting attachment.
11.17 Remove chips.

RELATED ACADEMIC STANDARDS OF LEARNING
(Based on 1995 SOLs)

MATH		TECHNICAL COMPETENCY
G.12	The student will make a model of a three-dimensional figure from a two dimensional drawing and make a two-dimensional representation of a three-dimensional object. Models and representations will include scale drawings, perspecitve drawings, blueprints, or computer simulations.	11.7
T.9	The student will identify, create, and solve practical problems involving triangles and vectors. Techniques will include using the trigonometric functions, the Pythagorean Theorem, the Law of Sines, and the Law of Cosines.	11.7, 11.8

DUTY AREA
11. OPERATING MILLING MACHINES

COURSE
Precision Machining Technology II (8540)
MAC 205

TASK / COMPETENCY
11.1 Align the milling machine head and fixtures.

PERFORMANCE OBJECTIVE
P11.1 Given a vise, access to a milling machine, clamping bolts, dial indicator attachment, and plastic mallet, align the milling machine head and fixtures. The vise must be aligned on the milling machine bed or table within 0.001" total runout. Demonstration should include cleaning techniques on the table and vise, sweeping the table to align the head, bolting and holding techniques for the vise, and use of the dial indicator, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M11.1 Demonstration, alignment accurate to within 0.001" total runout and all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate cleaning techniques on the table and vise.
2. Select the proper vise for the job.
3. Sweep the table to align the head.
4. Demonstrate bolting and holding techniques for the vise.
5. Set up and use the dial indicator with a given accuracy.

DUTY AREA
11. OPERATING MILLING MACHINES

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
11.2 Mount and align milling machine attachments.

PERFORMANCE OBJECTIVE
P11.2 Given a 90-degree milling attachment, access to a milling machine, extended draw bar, magnetic post, dial indicator, plastic mallet, hex wrench, and mill wrench, mount and align milling machine attachments to within 0.001" per 4". Demonstration should include cleaning the spindle attachment and setting the dial indicator and table mount, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M11.2 Demonstration, mounting accurate to within 0.001" per 4" and all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify the major parts of the mill.
2. Identify the size and type of spindle tool holder.
3. Clean the spindle attachment.
4. Set the attachment in place and tighten.
5. Demonstrate the proper setting of the dial indicator and table runout.

DUTY AREA
11. OPERATING MILLING MACHINES

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
11.3 Select and set speeds and feeds for milling work.

PERFORMANCE OBJECTIVE
P11.3 Given access to a milling machine, a blueprint, and a manufacturer's operational manual for the milling machine, select and set speeds and feeds for milling work as specified in the operational manual. Demonstration should include identification of safety precautions, explanation of the relationship between load-per-tooth and inches-per-minute, and changing of machine gears, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M11.3 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify safety precautions.
2. Explain load-per-tooth in relation to inches-per-minute.
3. Demonstrate changing machine gears.

DUTY AREA
11. OPERATING MILLING MACHINES

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
11.4 Perform end milling.

PERFORMANCE OBJECTIVE
P11.4 Given a blueprint, a *Machinist's Handbook*, workpiece with layout lines, access to a milling machine and accessories, work-holding device, plastic mallet or lead hammer, end mills, dial indicator, and precision measurement instruments, perform end milling to blueprint specifications. Demonstration should include observation of all safety precautions, use of mallet, hammer, and measurement instruments, and use of parallel bars, according to instructor's guidelines.

PERFORMANCE MEASURE
M11.4 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify safety precautions.
2. Demonstrate use of a plastic mallet or lead hammer.
3. Demonstrate use of precision measurement instruments for end-milling operations.
4. Demonstrate machining of a workpiece to specifications.
5. Explain "up" and "down" milling and the advantages or disadvantages of each.
6. Set up and use parallel bars.

DUTY AREA
11. OPERATING MILLING MACHINES

COURSE
Precision Machining Technology I (8539)
MAC 205

TASK / COMPETENCY
11.5 Perform flycutting operations.

PERFORMANCE OBJECTIVE
P11.5 Given a blueprint, workpiece, access to a milling machine and accessories, work-holding device, plastic mallet, flycutter, dial indicator, and precision measurement instruments, perform flycutting operations. The bar square and the parallel must be flycut to blueprint specifications, and all safety precautions must be observed in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M11.5 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify safety precautions.
2. Explain the differences and advantages of flycutting over end milling.
3. Explain special tool geometry.
4. Explain tool alignment.
5. Explain tool movement-bounce.
6. Rough-cut and finish-cut the workpiece to specifications.

DUTY AREA
11. OPERATING MILLING MACHINES

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
11.6 Drill holes, using a milling machine.

PERFORMANCE OBJECTIVE
P11.6 Given a blueprint, workpiece, access to a milling machine and accessories, work-holding device, plastic mallet, dial indicator, edge finder, precision measurement instruments, wiggler, combination drill and countersink, drills, and drill chuck, drill holes, using a milling machine, to blueprint specifications. Demonstration should include layout and center-punch techniques, use and sequence of center drill, drill, and conversion, use of various cutting-tool holding devices and adaptors, and use of the edge finder and wiggler, according to instructor's guidelines.

PERFORMANCE MEASURE
M11.6 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate layout and center-punch techniques.
2. Demonstrate use and sequence of center drill, drill, and conversion.
3. Demonstrate the various cutting-tool holding devices and adaptors.
4. Demonstrate hand drilling and automatic feed.
5. Define the difference between drill and mill feed rates.
6. Demonstrate use of the edge finder and wiggler.

DUTY AREA
11. OPERATING MILLING MACHINES

COURSE
Precision Machining Technology I (8539)
MAC 106, 206

TASK / COMPETENCY
11.7 Mill an angle.

PERFORMANCE OBJECTIVE
P11.7 Given a blueprint, a pre-machined workpiece, access to a mill and accessories, work-holding device, angle plate, 5" sine bar, set of jo blocks, precision measurement instruments, and vernier bevel protractor, mill an angle. The workpiece must be milled to an angle and a height specified on the blueprint, with the angle milled to a tolerance of ± 5 minutes. Demonstration should include planning the layout from the blueprint, setting up the milling machine, and using measuring instruments and the protractor, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M11.7 Demonstration, angle milled to a tolerance of ± 5 minutes, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Plan the layout, using the blueprint.
2. Set up the milling machine.
3. Demonstrate setup procedures, using the sine bar and jo blocks.
4. Explain how to select and use measuring instruments required in milling an angle.
5. Demonstrate use of the protractor.

DUTY AREA
11. OPERATING MILLING MACHINES

COURSE
Precision Machining Technology II (8540)
MAC 107, 205

TASK / COMPETENCY
11.8 Mill arcs.

PERFORMANCE OBJECTIVE
P11.8 Given a blueprint, workpiece, access to a mill and accessories, work-holding device, turntable, cutter tool, and precision measurement instruments, mill arcs. The cylindrical workpiece must be milled to blueprint specifications, and all safety precautions must be observed in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M11.8 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify safety precautions for milling arcs.
2. Identify the types of work-holding devices (rotary, table, index head, etc.).
3. Demonstrate work-holding devices for different work shapes.
4. Set up and use a turntable.
5. Set up and align the center of the spindle to the center of the work.
6. Demonstrate milling techniques for producing arcs.

DUTY AREA
11. OPERATING MILLING MACHINES

COURSE
Precision Machining Technology II (8540)
MAC 205

TASK / COMPETENCY
11.9 Perform reaming operations.

PERFORMANCE OBJECTIVE
P11.9 Given a blueprint, workpiece, work-holding device, access to a mill with accessories, chuck, combination drill and countersink, drills, reamers, and precision measurement instruments, perform reaming operations to blueprint specifications with a tolerance of 0.000" to 0.005". Demonstration should include use of the automatic feed in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M11.9 Demonstration, holes drilled and reamed to a tolerance of 0.000" to 0.005" and all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify and classify the material of the workpiece.
2. Mount and align the work-holding device.
3. Demonstrate use of reamers.
4. Set up and demonstrate the automatic feed.

DUTY AREA
11. OPERATING MILLING MACHINES

COURSE
Precision Machining Technology II (8540)
MAC 205

TASK / COMPETENCY
11.10 Cut external keyways.

PERFORMANCE OBJECTIVE
P11.10 Given a blueprint, a *Machinist's Handbook*, access to a milling machine and accessories, work-holding device, cutter, workpiece, and precision measurement instruments, cut external keyways to blueprint specifications of depth and distance. The demonstration should include laying out the keyway according to the blueprint, selecting the proper cutter for the keyway, selecting proper feeds and speeds, and observation of safety precautions, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M11.10 Demonstration, keyways cut to a specified accuracy and all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Lay out the keyway according to the blueprint.
2. Mount the proper work-holding device.
3. Identify the different types of keys.
4. Select the proper cutter for the keyway.
5. Identify the safety precautions for milling an external keyway.
6. Explain the selection of proper feeds and speeds.
7. Demonstrate the setup techniques to line up work on the axis and location.
8. Measure the stock for accuracy.

DUTY AREA
11. OPERATING MILLING MACHINES

COURSE
Precision Machining Technology II (8540)
MAC 106

TASK / COMPETENCY
11.11 Bore holes, using a milling machine.

PERFORMANCE OBJECTIVE
P11.11 Given a blueprint, workpiece, access to a mill and accessories, holding fixtures, dividers, rule, layout dye, mill wiggler, drill chuck, combination drill and countersink, drills, boring attachments, plug gauge, and micrometer calipers, bore holes, using a milling machine, to blueprint specifications. Demonstration should include use of the mill wiggler and the boring head and its tool geometry with an accuracy of ± 0.005" in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M11.11 Demonstration, holes bored to an accuracy of ±0.005" and all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate use of layout tools and techniques.
2. Demonstrate use of holding fixtures and adaptors.
3. Demonstrate use of a mill wiggler.
4. Demonstrate use of a boring head and its tool geometry.
5. Demonstrate use and sequence of procedures to drill, bore, and check the bore for accuracy.

DUTY AREA
11. OPERATING MILLING MACHINES

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
11.12 Perform form milling.

PERFORMANCE OBJECTIVE
P11.12 Given a blueprint, workpeice, work-holding device, access to a milling machine and accessories, form ground milling cutter, dial indicator, and precision measurement instruments, perform form milling to blueprint specifications. Demonstration should include selecting proper form cutters according to blueprint specifications and use of a dial indicator for precision measurement in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M11.12 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify safety precautions in performing form milling.
2. Read the blueprints for job specifications.
3. Select form cutters according to blueprint specifications.
4. Describe a form ground milling cutter.
5. Demonstrate use of a dial indicator for precision measurement.

DUTY AREA
11. OPERATING MILLING MACHINES

COURSE
Precision Machining Technology II (8540)
MAC 107, 206, 225

TASK / COMPETENCY
11.13 Perform indexing operations.

PERFORMANCE OBJECTIVE
P11.13 Given a blueprint with specifications, workpiece, access to a milling machine and accessories, work-holding device, milling cutter, aligning devices, dividing head and accessories, and precision measurement instruments, perform indexing operations, following the indexing specifications on the blueprint. Demonstration should include use of precision measurement instruments and observation of safety precautions in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M11.13 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify safety precautions in performing indexing operations.
2. Read blueprints for indexing specifications.
3. Describe the dividing head and accessories.
4. Outline the steps for simple and compound indexing.
5. Demonstrate use of precision measurement instruments used for indexing operations.

DUTY AREA
11. OPERATING MILLING MACHINES

COURSE
Precision Machining Technology II (8540)
MAC 206, 225

TASK / COMPETENCY
11.14 Mill gears.

PERFORMANCE OBJECTIVE
P11.14 Given a blueprint, a *Machinist's Handbook*, access to a mill with accessories, gear blank, gear, cutter, mandrel, dividing head, tailstock, steady rest, and precision measurement instruments, mill gears to blueprint and *Machinist's Handbook* specifications. Demonstration should include selection of cutters by the number of teeth and the diametrical pitch and its proper pressure angle, calculation of gear dimensions, and observation of safety precautions, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M11.14 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify safety precautions in milling a gear.
2. Read the blueprints for gear specifications.
3. Explain use of the *Machinist's Handbook* in milling gears.
4. Describe mill cutting to specifications.
5. Explain the selection of cutters by the number of teeth and the diametrical pitch and its proper pressure angle.
6. Cut the gear to the dimensions specified by the instructor.
7. Perform calculations of gear dimensions.

DUTY AREA
11. OPERATING MILLING MACHINES

COURSE
Precision Machining Technology II (8540)
MAC 225

TASK / COMPETENCY
11.15 Perform straddle-milling operations on the horizontal mill.

PERFORMANCE OBJECTIVE
P11.15 Given a blueprint, access to a horizontal milling machine and accessories, vise, side-milling cutters, milling machine arbor, parallels, rule, square, feeler gauge, micrometer caliper, scriber, and soft hammer, perform straddle-milling operations on the horizontal mill to an accuracy of ±0.002". Demonstration should include use of tools listed above and observation of all safety precautions in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M11.15 Demonstration, workpiece straddle-milled to an accuracy of ±0.002" and all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify safety precautions for operation of the horizontal mill.
2. Read the blueprints for job specifications.
3. Demonstrate use of a side-milling cutter.
4. Demonstrate use of parallels, rulès, squares, and feeler gauges.
5. Demonstrate use of a micrometer, scribe, and soft hammer.
6. Explain the advantages of straddle-milling, using conventional or up milling as opposed to climb down milling.

DUTY AREA
11. OPERATING MILLING MACHINES

COURSE
Precision Machining Technology II (8540)
MAC 107

TASK / COMPETENCY
11.16 Mill internal slots, using a slotting attachment.

PERFORMANCE OBJECTIVE
P11.16 Given a blueprint, workpiece, work-holding device, access to a vertical mill and accessories, slotting attachment, slotting cutter or tooi, and precision measurement instruments, mill internal slots, using a slotting attachment, to a tolerance of ±0.001". Demonstration must observe all safety precautions and be in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M11.16 Demonstration, slots milled to a tolerance of ±0.001" and all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify safety precautions for milling an internal slot using a slotting attachment.
2. Read the blueprints for job specifications.
3. Demonstrate the use of slotting attachments.

DUTY AREA
11. OPERATING MILLING MACHINES

COURSE
Precision Machining Technology I (8539)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
11.17 Remove chips.

PERFORMANCE OBJECTIVE
P11.17 Given a "T" slot chip tool, wet and dry vacuum, shop towels, safety glasses, chip pans, chip containers, and access to a machine, remove chips from the work area. Work location, machine, and floor area around machine must be free of chips and cutting fluids, and all safety precautions must be observed, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M11.17 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify safety precautions for removing chips.
2. Turn off power to all machine axis movements.
3. Demonstrate use of eye protection needed for machine cleanup.
4. Clean chips and cutting fluids from fixture, table, and chip pan.
5. Clean chips from machine body, base, and floor area around machine.

DUTY AREA 12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

12.1 Develop programmed instructions from blueprint.
12.2 Develop programmed instructions from sample part.
12.3 Develop a production plan.
12.4 Choose machine tools for part.
12.5 Select tools and holders.
12.6 Select spindle speeds and feeds.
12.7 Position workpiece in relation to machine axis.
12.8 Select absolute or incremental mode.
12.9 Determine polar/rectangular coordinates.
12.10 Verify cutter path.
12.11 Depict part graphically.
12.12 Program tool-change procedure.
12.13 Prepare operator instructions for piece part.
12.14 Select canned cycles.
12.15 Program restart points.
12.16 Enter tool offset.
12.17 Load tools in caddy.
12.18 Check tooling sheet.
12.19 Install cutting tools in holders.
12.20 Call up program in distributed numerical control.
12.21 Mount holder and tool on spindle manually.
12.22 Load automatic tool changer.
12.23 Mount workpiece.
12.24 Set zero coordinates.
12.25 Dry run program.
12.26 Edit program.
12.27 Alter spreed/feed commands.
12.28 Key in program on machine.
12.29 Complete machine tool safety set up.
12.30 Align holding device with machine axis.
12.31 Change tool holder.
12.32 Modify data input program.
12.33 Set manual mode control.
12.34 Turn on power.
12.35 Interpret status lights.
12.36 Perform sequence search.
12.37 Restart interrrupted program from zero.
12.38 Check cutting fluids.
12.39 Check surface finish.
12.40 Index turret.
12.41 Differentiate among machine controls.
12.42 Change cutting tool.
12.43 Adjust tool offset manually.
12.44 Execute emergency stop.
12.45 Activate automatic cycle mode.
12.46 Interrupt automatic cycle mode manually.
12.47 Run segment of program.
12.48 Interpret operator-related screen messages.

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RELATED ACADEMIC STANDARDS OF LEARNING

(Based on 1995 SOLs)

MATH		TECHNICAL COMPETENCY
A.1	The student will solve linear equations and inequalities in one variable, solve literal equations (formulas) for a given variable and apply these skills to solve practical problems. Graphing calculators will be used to confirm algebraic solutions.	12.4
A.2	The student will represent verbal quantitative situations algebraically and evaluate these expressions for given replacement values of the variables. Students will choose an appropriate computational technique, such as mental mathematics, calculator, or paper and pencil.	12.4
COM.1	The student will describe the program development cycle: defining the problem, planning a solution, carrying out the plan, debugging the program, and providing program documentation.	12.1, 12.2
COM.2	The student will write program specifications that define the constraints of a given problem. These specifications include descriptions of pre-conditions, post-conditions, the desired output, analysis of the available input, and an indication as to whether or not the program is solvable under the given conditions.	12.1, 12.2, 12.3
COM.8	The student will design and implement computer graphics, which will include topics appropriate for the available programming environment as well as student background. Students will use graphics as an end in itself, as an enhancement to other output, and as a vehicle for reinforcing programming techniques.	12.11
COM.18	The student will test a program using an appropriate set of data. The set of test data should be appropriate and complete for the type of program being tested.	12.25

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.1 Develop programmed instructions from blueprint.

PERFORMANCE OBJECTIVE
P12.1 Given access to a computer, software, a calculator, and a blueprint, develop programmed instructions for the CNC machine from blueprint dimensions and within tolerance standards set by the instructor. Demonstration should include specifying all setup and operational parameters, documenting the sequence of operations, and preparing explicit operator instructions, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M12.1 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Determine sequence of operations.
2. Establish reference point to align workpiece and machine tool.
3. Specify cutting tool.
4. Specify feeds and speeds of cutting tool.
5. Specify location of holding devices in reference to machine table and workpiece.
6. Specify spindle rotation, coolant flow, and table indexing, depending on type of machine tool used.
7. Prepare list of machining instructions in a format that can be used by the particular control unit/ machine tool combination.
8. Examine list to determine
   a. first machining operation
   b. sequencing of remaining machining operations.
9. Develop manuscript to document sequence of operations.
10. Prepare explicit operator instructions.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.2 Develop programmed instructions from sample part.

PERFORMANCE OBJECTIVE
P12.2 Given a piece part, caliper, micrometer, measuring instrument, access to a computer, software, and calculator, develop programmed instructions for the CNC machine from sample part. Instructions must meet piece part and print or sketch dimensions within tolerance standards set by the instructor. Demonstration should include making and dimensioning a sketch of the part and specifying all setup and operational parameters, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M12.2 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Measure machined surface.
2. Make a print or sketch.
3. Dimension the sketch.
4. Determine sequence of operations
5. Establish reference point to permit alignment of workpiece and machine tool.
6. Specify cutting tools.
7. Specify setting of feeds and speeds.
8. Specify location of holding devices.
9. Specify spindle rotation, coolant flow, and table indexing, depending on type of machine tool used.
10. Prepare a list of machining instructions in a format that can be used by the particular control unit/ machine tool combination.
11. Examine list to determine
    a. first matching operation
    b. sequence of remaining machining operations.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 106, 107, 206

TASK / COMPETENCY
12.3 Develop a production plan.

PERFORMANCE OBJECTIVE
P12.3 Given a production plan form and list of key process terms, develop a production plan which lists all steps to follow in the machining of a workpiece. Plan must contain all steps needed to machine a workpiece with steps listed in proper order and with key process verbs used to begin each step.

PERFORMANCE MEASURE
M12.3 Student-produced production plan, all components meeting instructor's specifications

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Determine the steps needed to machine a workpiece.
2. Select the key process verbs (i.e., mill, turn, saw, bore, drill, etc.) to begin each process step.
3. Arrange the steps in proper order.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 225, 245

TASK / COMPETENCY
12.4 Choose machine tools for part.

PERFORMANCE OBJECTIVE
P12.4 Given cutting tool list, CNC machine tools, *Machinery's Handbook*, and blueprint for piece part, choose machine tools for part. Tools must be selected to yield the most efficient output and highest productivity in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M12.4 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Determine type of material to be machined.
2. Establish machining process, combining operations when possible.
3. Select automatic tool changers for multiple cutting tool operations.
4. Determine machine tool loading and unloading requirements for process.
5. Evaluate machining requirements to minimize labor and machine operating costs.
6. Match piece part production to machine tool on which operation can be most efficiently performed.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 225, 245

TASK / COMPETENCY
12.5 Select tools and holders.

PERFORMANCE OBJECTIVE
P12.5 Given cutting tools, tool holders, cutting tool numbers, cutter diameters, tool length compensation values, piece part specifications, tooling policies and standards, and operator's programming manual, select tools and holders. Tools must create piece part according to specifications, and holders must fit cutting tools. Demonstration should include checking tool dimensional standards for precision tolerances, selecting tools and holders on basis of type, specific cutting edge, materials, diameter, and maximum tool length, and creating a tool list, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M12.5 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Outline machining procedures.
2. Check cutting tool dimensional standards for precision tolerances.
3. Select shortest and most rigid cutting tool that can be applied to job.
4. Use graded carbide and carbide indexable-insert type tools whenever possible in preference to high-speed steel.
5. Use commercial, pre-set, or qualified types of tools for lathe operations.
6. Identify tools and holders on basis of type, specific cutting edge, materials, diameter, and maximum tool length.
7. Check for tool holders and cutting tool numbers on operation of procedure sheet.
8. Enter cutting tool numbers or program sequence numbers in computer program, using specific machine tool manufacturer's programming manual as a reference.
9. Make up tool list for machine setup and operation.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 106, 107, 206

TASK / COMPETENCY
12.6 Select spindle speeds and feeds.

PERFORMANCE OBJECTIVE
P12.6 Given access to a computer, *Machinery's Handbook*, and material characteristics, select spindle speeds and feeds as specified in the Handbook. Demonstration should include determining machining process, identifying the type of material to be machined, and converting the cutting rate to revolutions-per-minute, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M12.6 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Determine type of machining process to be used (i.e., drilling, reaming, turning).
2. Identify type of material to be machined.
3. Determine diameter of cutter.
4. Identify from the *Machinery's Handbook* the standard value cutting rate. Note: Use constant surface feed-per-minute when available on machine.
5. Convert cutting rate to revolutions-per-minute, using formula: rpm (revolution-per-minute) = sfm (surface-feet-per-minute) x constant (3.1416) ÷ d (diameter of cutter).
   Note: Cutting rate is measured in inches-per-minute (IPM) or meters-per-minute (MPM).

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 106, 107, 206

TASK / COMPETENCY
12.7 Position workpiece in relation to machine axis.

PERFORMANCE OBJECTIVE
P12.7 Given access to computer, software, CNC machine tool, print specifications, and workpiece, position workpiece in relation to machine axis to allow complete machining of part without axis overtravel or clearance problems. Demonstration must include establishing datum plane or set point in relation to machine axis and comparing datums and ordinate dimensioning, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M12.7 Demonstration, rated acceptable on instructor-provided checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Determine size of piece part and/or work holding device.
2. Check manual for axis travel range of specific machine tool.
3. Establish datum plane or set point in relation to machine axis, using the following guidelines:
   a. Long side of the part surface corresponds to the X axis.
   b. Short side of the part surface corresponds to the Y axis.
   c. Depth of the part corresponds to the Z axis.
4. Determine datum plane in exceptional cases by the method of clamping, the geometry of the part, or the area to be cut.
5. Compare datums and ordinate dimensioning in order to establish machining guidelines.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 125

TASK / COMPETENCY
12.8 Select absolute or incremental mode.

PERFORMANCE OBJECTIVE
P12.8 Given access to a computer, print specifications, piece part, and CNC machine tool, select absolute or incremental mode as specified by machine code on machine program or control panel of tool. Demonstration must include assessment of piece part for accuracy and tolerance required and complexity of contour milling required in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M12.8 Demonstration, rated acceptable on instructor-provided checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Assess piece part detail for
   a. number of locations that require accurate drilling, boring, reaming, tapping, or turning
   b. number of locations that require straight or contour milling
   c. tolerance and accuracy required
   d. complexity of contour shapes in piece part.
2. Select incremental mode if
   a. accuracy and tolerance do not present any problems
   b. little or no contour milling is required.
3. Select absolute mode if
   a. close tolerances and high accuracy are required
   b. complex contour milling is required
   c. cutting tool location must be determined in relation to a specific datum point.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 125

TASK / COMPETENCY
12.9 Determine polar/rectangular coordinates.

PERFORMANCE OBJECTIVE
P12.9 Given access to a computer, manufacturer's programming manual, and print specifications, determine polar/rectangular coordinates needed to complete the workpiece according to blueprint specifications. Demonstration must include determining allowable tolerances for the part, dimensioning the part, analyzing surface irregularities, and defining the part. Optimum results from the CNC equipment must be obtained according to instructor's guidelines.

PERFORMANCE MEASURE
M12.9 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Determine the part specifications from the blueprint.
2. Define part surfaces from three mutually perpendicular reference planes.
3. Establish reference planes along part surfaces that parallel the machine axes.
4. Dimension from a physical point on the part surface.
5. Determine allowable tolerances for the part.
6. Analyze surface irregularities on sculptured surfaces of the part.
7. Dimension the part to determine physical shape without downstream calculations and assumptions.
8. Describe or define the part to permit cutter path to be accurately defined.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.10 Verify cutter path.

PERFORMANCE OBJECTIVE
P12.10 Given access to a computer, computer graphics software, pen-type plotter, templates, pencil, print specifications, and part one of part program, verify cutter path. Verified path must provide documentation of piece part outline and cutter clearance and must meet blueprint specifications and standards. Demonstration should include plotting cutter path using pen plotter and/or computer-generated graphics in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M12.10 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Complete procedures necessary to define cutter path.
2. Plot cutter path using pen plotter:
   a. Construct circles along plotted cutter path to represent a cutter, using plastic templates.
   b. Develop drawing showing cutter path in relation to fixture to determine possible interference.
3. Plot cutter path using computer-generated graphics:
   a. Enter GL geometry.
   b. Generate cutter path on CRT screen and/or plotter.
4. Prepare verified cutter path documentation for use in setting up and operating machine.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 225

TASK / COMPETENCY
12.11 Depict part graphically.

PERFORMANCE OBJECTIVE
P12.11 Given access to a CAD/CAM software program and part print, depict the part graphically, creating actual machine commands or the computer statements necessary for generating machine codes. Demonstration should include loading the software, creating, rotating, enlarging, and zooming in on specific features, and directing cutter to move along a line, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M12.11 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Load system software.
2. Create and design elements to appear on a CRT screen.
3. Rotate, enlarge, and zoom in on specific design features, if software program permits.
4. Call up a line and direct cutter to move along it.
5. Complete design functions, using workpiece database.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.12 Program tool-change procedure.

PERFORMANCE OBJECTIVE
P12.12 Given tool holders, cutting tools, tool position number, tool identification numbers, manufacturer's programming manual, and storage matrix capacity of machine tool, program tool-change procedure. Program must provide tool identification numbers, which permit calling up tool from the storage matrix to the assigned tool position in order to provide a basis for repetitive tool selection. Demonstration should include determining sequence of operations to allow for minimal tool changes, entering tooling in program in sequential order, specifying spindle speeds and feeds, and establishing tool offset values, according to instructor's guidelines.

PERFORMANCE MEASURE
M12.12 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify tool numbers.
2. Identify tool position numbers when using automatic tool changer.
3. Identify information needed to set tool matrix, if machine tool does not provide automatic tool changer.
4. Determine sequence of operations to allow for minimal tool changes.
5. Enter tooling in program in sequential order, according to manufacturer's programming manual.
6. Specify spindle speeds and feeds for each tool.
7. Establish tool offset values, if needed.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 245

TASK / COMPETENCY
12.13 Prepare operator instructions for piece part.

PERFORMANCE OBJECTIVE
P12.13 Given access to a computer, pencil, tooling sheet, setup sheet, operator instruction sheet, and a piece part, prepare operator instructions for a piece part. Demonstration must include determining procedures that require operator assistance and must provide sufficient information to implement programmed machine commands to complete all machining processes for the part in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M12.13 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Review machining sequence.
2. Determine procedures that require operator assistance or intervention:
   a. tool changes
   b. unusual positioning of work piece.
3. Enter operator messages in computer:
   a. Enter edit mode.
   b. Make additions in sequential blocks, or
   c. Hand-write operator messages on computer printout or setup sheet.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.14 Select canned cycles.

PERFORMANCE OBJECTIVE
P12.14 Given access to a CNC machine and the manufacturer's programming manual for a specific machine tool, select canned cycles so that the machine tool performs the canned cycle functions initiated by the CNC machine program.

PERFORMANCE MEASURE
M12.14 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify canned cycles for a specific CNC machine.
2. Select canned cycles for a combination of machine moves.
3. Choose area of program where canned cycle can be used.
4. Insert codes to execute canned cycle, according to manufacturer's programming manual.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.15 Program restart points.

PERFORMANCE OBJECTIVE
P12.15 Given access to a computer, software, piece part specifications, verified cutter path, and the manufacturer's operating/programming manual, program restart points to be activated when program is interrupted by tool breakage, machine tool failure, operator error, or emergency conditions. Demonstration must include determination of possible safe-start locations along the cutter path in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M12.15 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Activate automatic restart or safe-start option on machine control.
2. Determine possible restart points or safe-start locations along cutter path.
3. Enter restart or safe-start points and other program information necessary to restart machining process safely, according to programmer's manual for type of computer/software used.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.16 Enter tool offset.

PERFORMANCE OBJECTIVE
P12.16 Given format classification sheet and a programming system with cutter compensation system, enter tool offset. Tool offset value that corresponds to tool offset number must be added to the commanded value in the program, and the tool must be moved to the offset position. Demonstration must include specifying and entering tool position by using command codes in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M12.16 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Specify tool selection position.
2. Specify tool offset number for offset value.
3. Enter tool position by using command codes specified by software format classification sheet.
4. Enter tool offset value using command codes specified by software format classification sheet (may be done also at machine using offset input dial and offset load button).

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 245

TASK / COMPETENCY
12.17 Load tools in caddy.

PERFORMANCE OBJECTIVE
P12.17 Given access to a storage area, a tool caddy, tools, and a tooling sheet, load tools in caddy in correct sequence. Demonstration must include observation of all safety precautions for handling tools in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M12.17 Demonstration, all procedures performed with 100% accuracy and rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Interpret tooling sheet.
2. Locate tool caddy.
3. Load tools in caddy.
4. Return tools and caddy to storage.
5. Use proper safety techniques for handling tools.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.18 Check tooling sheet.

PERFORMANCE OBJECTIVE
P12.18 Given a blueprint and tooling sheet, check tooling sheet against blueprint to ensure 100% accuracy of tooling for the job. Demonstration should include checking the sequence of tooling as well as the tooling required in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M12.18 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Interpret tooling sheet.
2. Interpret blueprint.
3. List tooling needed as required by blueprint.
4. Check sequence of tooling.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.19 Install cutting tools in holders.

PERFORMANCE OBJECTIVE
P12.19 Given adapters, cutting tools, tooling sheet, access to a CNC machine, and tool holders (arbor, fixed lock, and collet), install cutting tools in holders. Entire holder and cutting tool setup must be within the program's working tolerances and must remain secure during machining process. Demonstration should include selecting holders to fit tools, cleaning pockets or turrets of tool drums before loading, and tightening tools in holders, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M12.19 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Check tooling sheet for cutting tool size to be used.
2. Select holder to fit cutting tool.
3. Check the combined length of tool holder and tool against requirements of program.
4. Clean turret or pocket of tool drum before loading.
5. Place cutting tool in holder and tighten.
6. Use one of the following methods to tighten cutting tool in holder:
   a. Tighten set screw in holder.
   b. Tighten collet around holder, using wrench.
   c. Tighten cutting tool in drill chuck, using chuck key.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.20 Call up program in distributed numerical control.

PERFORMANCE OBJECTIVE
P12.20 Given software, data communications system, format sheet, access to a mainframe computer, and a group of numerically controlled machines, call up program in distributed numerical control so that program to produce workpiece is available in machine memory when cycle start is activated. Machine tool must be prepared to receive CNC data, and data must be downloaded to machine control unit in accordance with tool operating manual, software system's format sheet, and instructor's guidelines.

PERFORMANCE MEASURE
M12.20 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Enter code name or number for entering software system.
2. Call up directory of programs available.
3. Check machine tool operating manual and software system's format classification sheet for specialized systems instructions.
4. Enter required program by name or number.
5. Check program in computer:
   a. Check for condition of program.
   b. Contact CNC programmer if program is not available.
6. Prepare machine tool to receive CNC data, according to manufacturer's operating manual.
7. Download data from computer to machine control unit.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.21 Mount holder and tool on spindle manually.

PERFORMANCE OBJECTIVE
P12.21 Given access to a CNC machine, tool holder, automatic drawbar or cam wrench, mount holder and tool on spindle manually. Holder and tool must remain secure in machine spindle during machine operations. Demonstration should include cleaning spindle and tool holder, selecting tools, and mounting with and without automatic drawbar, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M12.21 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Clean spindle.
2. Determine if tool holder is free of chips.
3. Select tool to be used.
4. Mount without automatic drawbar:
   a. Place tool holder in spindle opening.
   b. Rotate tool holder in spindle.
   c. Place cam wrench on slotted collar of spindle and rotate wrench counterclockwise until collar tightens down on tool holder.
5. Mount with automatic drawbar:
   a. Hold tool holder up near spindle opening and push tool change button.
   b. Insert tool holder into spindle and release tool change button.
6. Set tool length compensation, if required.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 125, 225, 245

TASK / COMPETENCY
12.22 Load automatic tool changer.

PERFORMANCE OBJECTIVE
P12.22 Given tools, tool holders, tooling setup sheet, tool identification numbers, tool pocket locations, program with automatic tool changer, and manufacturer's instructions for automatic tool changer, load the automatic tool changer so that the tool is loaded into spindle when tool number is called up in program. Tools must be checked for chips, burrs, and orientation, and loaded tool drum, turret, or magazine should not exceed manufacturer's recommended specifications for total tools, maximum weight, length, and dimension of cutting tools.

PERFORMANCE MEASURE
M12.22 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Check to ensure tools are free from chips and burrs.
2. Check orientation of special tools.
3. Use jog tool drum, turret, or magazine push button to select desired tool pocket.
4. Check that machine is not in cycle.
5. Insert tool in pocket.
6. Secure each tool and tool holder as specified by program's setup sheet.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.23 Mount workpiece.

PERFORMANCE OBJECTIVE
P12.23 Given a fixture with clamps, holding device, access to CNC machine, and piece part, mount the workpiece in fixture so that it is rigid and secure without piece part movement. Demonstration should include cleaning table and fixture, if necessary, attaching fixture to table, and using caution to avoid damaging workpiece, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M12.23 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Clean table and fixture, if necessary.
2. Attach fixture to table.
3. Place piece part in fixture.
4. Clamp and hold piece in position by aligning part with positioning blocks.
5. Use caution to avoid damaging workpiece through mishandling.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.24 Set zero coordinates.

PERFORMANCE OBJECTIVE
P12.24 Given access to a CNC machine, blueprint/setup sheet, and manufacturer's operating manual, set the zero coordinates so that the axis displayed on CRT screen registers as zero coordinates. Demonstration should include ascertaining the starting position from blueprint or setup sheet and locating and moving to starting position on workpiece by using necessary instruments, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M12.24 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Read blueprint or setup sheet for specified starting position.
2. Locate and move to starting position on workpiece by using necessary instruments:
   a. dial indicator
   b. piece part stop
   c. edge finder.
3. Set machine according to special requirements as indicated in manufacturer's operating manual.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.25 Dry run program.

PERFORMANCE OBJECTIVE
P12.25 Given CNC machine tool, safety glasses, CNC vertical mill, safety shoes, CNC wire EDM, and safety rules for operating the machine in dry run, dry run a program so that it runs without observed error. Demonstration should include monitoring the machine for malfunction and observing all safety precautions, including wearing eye protection.

PERFORMANCE MEASURE
M12.25 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Load program in machine control.
2. For CNC machine tool
   a. Call up beginning of program.
   b. Switch control to dry run.
   c. Depress cycle start button.
3. For CNC vertical mill
   a. Set cutter depths so that cutter will not hit workpiece during dry run.
   b. Switch control to dry run.
   c. Depress cycle start button.
4. For CNC wire EDM
   a. Remove wire from guides.
   b. Position guides to clear workpiece, clamps, and machine limit switches.
   c. Switch control to dry run.
   d. Depress cycle start button.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.26 Edit program.

PERFORMANCE OBJECTIVE
P12.26 Given a part program, access to CNC machine, programmed manuscript, and manufacturer's operating manual, edit the program according to instructor-provided specifications and manufacturer's operating manual. Changes in the program must be verified on console, with programmed manuscript, or by a dry run through edited portion.

PERFORMANCE MEASURE
M12.26 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Activate edit mode.
2. Use keyboard to create, alter, and/or modify program, according to manufacturer's operating manual.
3. Verify changes in program on console or with programmed manuscript.
4. Dry run program through edited portion to verify the changes visually.
5. Create hard copy or programmed manuscript of edited and verified program.
6. Store hard copy or programmed manuscript.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.27 Alter speed/feed commands.

PERFORMANCE OBJECTIVE
P12.27 Given access to a CNC machine, cutting tools, machine control, blueprint, workpiece, and manufacturer's operating/programming manual, alter the speed/feed commands according to instructor-provided specifications and manufacturer's operating/programming manual. New speeds/feeds must be verified by observing machine control.

PERFORMANCE MEASURE
M12.27 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Determine amount of feed and spindle rpm increase or decrease.
2. Enter new spindle speed value into machine control, according to manufacturer's operating/programming manual for specific machine tool.
3. Verify new speeds/feeds by observing machine control.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.28 Key in program on machine.

PERFORMANCE OBJECTIVE
P12.28 Given CNC machine tool, calculator, machine control, part print specifications, mylar/paper tape, and manufacturer's operating manual, key in the program on machine. The CRT screen must indicate verification of program when operator calls up program by program name. Demonstration should include all steps for creating program at the control and for loading prepared program in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M12.28 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Create program at the control:
   a. Refer to part print specifications.
   b. Assign program number.
   c. Write manual program for machining sequence.
   d. Enter all information according to manufacturer's operating manual for specific machine tool.
   e. Edit program for errors.
   f. Dry run program.
   g. Download and store data to disk, tape, or cassette.
2. Key in (load) prepared program:
   a. Identify tape by tape number.
   b. Load program into machine.
   c. Run program off memory or off tape.
   d. Remove prepared tape for storage.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.29 Complete machine tool safety setup.

PERFORMANCE OBJECTIVE
P12.29 Given access to a CNC machine, safety shoes, safety glasses, and manufacturer's machine tool manual, complete machine tool safety setup, meeting all OSHA safety standards. Demonstration should include placement of all safety devices on machine and procedures for safe measuring of workpiece, loading and unloading of tools, and cleaning of machine.

PERFORMANCE MEASURE
M12.29 Demonstration, all items meeting OSHA safety standards and rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Place safety guards, shields, barriers, covers, and protective devices on machine.
2. Set up workpiece with clearance for cutting tool.
3. Stop spindle and slide when measuring workpiece.
4. Retract workpiece a safe distance from cutting tool when loading and unloading.
5. Remove chips and grit with a rake or brush.
6. Clear machine tools and table edge out of path of moving units.
7. Operate control panel without reaching over or through a machine.
8. Listen for excessive vibration or unusual sounds from machine.
9. Turn master disconnect to OFF position before cleaning machine.
10. Shut off power whenever leaving machining area.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 125, 225, 245

TASK / COMPETENCY
12.30 Align holding device with machine axis.

PERFORMANCE OBJECTIVE
P12.30 Given a work-holding device, tool holder, dial indicator, and a CNC machine tool, align the holding device with the machine axis. Work-holding device must be square and parallel to appropriate axes and must be aligned with machine axis to a tolerance of 0.0005"/1" to total indicator reading.

PERFORMANCE MEASURE
M12.30 Demonstration, holding device aligned with machine axis to within 0.0005"/1" to total indicator reading (T.I.R.) and all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Align edge of work-holding device with machine axis.
2. Tighten work-holding device down to table.
3. Place dial indicator in tool holder, collet, or arbor.
4. Place tool holder in spindle (does not apply when using magnetic base holder).
5. Place dial indicator contact point on edge of work-holding device relative to the appropriate axis.
6. Move table the length of the work-holding device along appropriate axis.
7. Watch dial indicator needle for movement.
8. Adjust work-holding device until dial indicator needle movement remains within the specified tolerance.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 125, 225, 245

TASK / COMPETENCY
12.31 Change tool holder.

PERFORMANCE OBJECTIVE
P12.31 Given wrenches, tool holder, access to a CNC machine, and manufacturer's operating manual, change the tool hold so that it remains in spindle. Demonstration must include all steps for changing tool holder manually or automatically, and holder must be mounted in spindle to instructor-specified tightness and alignment.

PERFORMANCE MEASURE
M12.31 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Change tool holder manually:
   a. Engage spindle break, as necessary.
   b. Loosen spindle locking collar while holding wrench firmly.
   c. Remove tool holder from spindle and place in tray.
   d. Place new tool holder in spindle.
   e. Tighten spindle locking collar.
   f. Release spindle brake, as necessary.
2. Change tool holder automatically:
   a. Follow manufacturer's operating manual to disengage tool holder automatically.
   b. Check new holder and the spindle for clearness and chips.
   c. Load tool holder according to manufacturer's operating manual.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 125, 225, 245

TASK / COMPETENCY
12.32 Modify data input program.

PERFORMANCE OBJECTIVE
P12.32 Given a CNC machine tool, control, workpiece, blueprint, and manufacturer's operating manual, modify the data input program. Data input program must be edited or newly created according to manufacturer's operating manual for the specific machine tool. Edited or created programs must be accepted by machine control unit and produce workpiece that meets the tolerances and dimensions specified on blueprint.

PERFORMANCE MEASURE
M12.32 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Turn on control.
2. Clear control of all entries.
3. Stop machine.
4. Activate manual data input mode according to manufacturer's operating manual for specific machine tool.
5. Select single block mode according to manufacturer's operating manual.
6. Edit current program:
   a. Select block in buffer to be edited.
   b. Identify block sequence number to be edited.
   c. Call up desired block sequence.
   d. Modify data, using manufacturer's operating manual.
7. Create new data input program, entering data by block or line.
8. Exit manual data input mode according to manufacturer's operating manual.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 125, 225, 245

TASK / COMPETENCY
12.33 Set manual mode control.

PERFORMANCE OBJECTIVE
P12.33 Given a CNC machine tool, control, and manufacturer's operating/programming manual, set the machine for manual mode according to instructions for codes and program format found in manufacturer's operating/programming manual. Control must indicate that manual mode is in operation.

PERFORMANCE MEASURE
M12.33 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Stop program.
2. Clear control of all entries.
3. Select manual mode on control according to manufacturer's operating/programming manual for codes and program format.
4. Verify entry of manual mode by observing control.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 117, 125, 225, 245

TASK / COMPETENCY
12.34 Turn on power.

PERFORMANCE OBJECTIVE
P12.34 Given access to a CNC machine and control unit, turn on the machine so that all machine control unit lights or indicators respond. Demonstration should include ensuring that machine tool has freedom of movement and checking the coolant pump and start positions, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M12.34 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Locate master control switch on control unit or machine panel.
2. Position control switch to ON.
3. Jog machine tool in all directions to make sure that all sides move freely.
4. Check the operation of the coolant pump by activating the coolant controls.
5. Check start positions shown on control panel display.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.35 Interpret status lights.

PERFORMANCE OBJECTIVE
P12.35 Given access to a CNC machine tool, control, and manufacturer's operating manual, interpret status lights and displays on the control unit, according to criteria in the manufacturer's operation manual, in order to maintain control of the machine tool. Interpretation must include determination of procedures to be followed when malfunction lights appear in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M12.35 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify status lights:
   a. temperature warning
   b. servo fault
   c. data error
   d. program changes
   e. power supply
   f. diagnostic.
2. Determine procedures to be followed:
   a. Review manufacturer's operating manual.
   b. Apply corrective measures for machine malfunction or notify maintenance or service personnel.
   c. Enter system commands to deactivate light.
3. Follow procedures to maintain control of the machine tool and continue the machining program.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 125, 225, 245

TASK / COMPETENCY
12.36 Perform sequence search.

PERFORMANCE OBJECTIVE
P12.36 Given access to a CNC machine, control, CNC program, and format classification sheet, perform sequence search. Search must locate specified block of information without running entire program and without physical damage to program.

PERFORMANCE MEASURE
M12.36 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Turn on power.
2. Clear control of all entries.
3. Enter program number to call up program.
4. Press page button for program number according to format classification sheet for CNC program being used.
5. Scroll forward or backward to desired page or line.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 125, 225, 245

TASK / COMPETENCY
12.37 Restart interrupted program from zero.

PERFORMANCE OBJECTIVE
P12.37 Given a CNC machine tool, control, and CNC program, restart an interrupted program from zero. Machine tool must be moved to zero position and tape rewound to a safe start-up block so that workpiece is completed according to specifications.

PERFORMANCE MEASURE
M12.37 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Return to original coordinates, using digital readouts, if provided.
2. Move machine tool to zero position.
3. Rewind the tape to safe start-up block.
4. Depress cycle start to restart program.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 125, 225, 245

TASK / COMPETENCY
12.38 Check cutting fluids.

PERFORMANCE OBJECTIVE
P12.38 Given coolant, control, a CNC machine tool, coolant concentration gauge, and manufacturer's maintenance manual, check the cutting fluids. Coolant indicators must show level of cutting fluids and or spray/mist coolant as recommended by manufacturer of machine. Demonstration should include determination of the concentration of the coolant, preparation of an appropriate coolant mixture, and addition of coolant to fill tank to prescribed level.

PERFORMANCE MEASURE
M12.38 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Check sight gauge for coolant level.
2. Use coolant concentration gauge to determine ratio of coolant to water.
3. Prepare mixture with appropriate ratio of coolant to water.
4. Add coolant recommended by manufacturer to fill tank to prescribed level.
5. Verify new fluid levels by observing dial indicator on control.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 125, 225, 245

TASK / COMPETENCY
12.39 Check surface finish.

PERFORMANCE OBJECTIVE
P12.39 Given part print, piece part, and surface comparator or other appropriate measuring device, check the surface finish. Surface finish of piece part must measure within the range of tolerances specified on part print.

PERFORMANCE MEASURE
M12.39 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Remove piece part from fixture.
2. Clean part before inspection.
3. Compare piece part surfaces for finish quality.
4. Use measuring devices to determine if piece part finish is within tolerances specified.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 225, 245

TASK / COMPETENCY
12.40 Index turret.

PERFORMANCE OBJECTIVE
P12.40 Given a CNC machine tool with turret and tool identification or location number, index the turret according to instructor-provided guidelines. Demonstration must include selection of tool position number on turret and location of desired turret station number.

PERFORMANCE MEASURE
M12.40 Demonstration, all steps rated acceptable on instructor-prepared checklist and tool position verified by instructor

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Select tool position number on turret.
2. Locate desired turret station number.
3. Index turret.
4. Repeat for each turret tool position selected.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 225

TASK / COMPETENCY
12.41 Differentiate among machine controls.

PERFORMANCE OBJECTIVE
P12.41 Given access to CNC machine, operator's manual, and the removal of all tooling and work-holding devices, differentiate among machine controls and indicators according to instructor-provided guidelines. Each indicator and control must be identified, its function described, and its function matched to a procedure to be initiated.

PERFORMANCE MEASURE
M12.41 Instructor-prepared checklist, all items rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify all lights, digital indicators, buttons, dials, switches, and keyboard on machine tool.
2. Describe function of each indicator and control.
3. Match function of each control to procedure to be initiated.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.42 Change cutting tool.

PERFORMANCE OBJECTIVE
P12.42 Given a wrench, tool holder, access to a CNC machine, sharp cutting tools, and the manufacturer's tooling manual, change cutting tool according to manufacturer's specifications. Tool holder must be cleaned before inserting new tool, and tool must be securely seated in tool holder.

PERFORMANCE MEASURE
M12.42 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Remove cutting tool from tool holder according to manufacturer's tooling manual.
2. Clean tool holder and insert new cutting tool.
3. Install tool holder with cutting tool into machine according to manufacturer's tooling manual.
4. Set pre-set tools to correct tool height.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.43 Adjust tool offset manually.

PERFORMANCE OBJECTIVE
P12.43 Given the appropriate fixtures, access to a CNC machine, tool holders, tool offset table, cutting tools, measuring instruments, piece part specifications, piece part, cutting tool sequence numbers, and safety glasses, adjust the tool offset manually. The offset adjustment must move cutting tool the amount needed to compensate for tool wear, finish cuts, and tool usage. Measurement of finished piece part must meet standards set by blueprint.

PERFORMANCE MEASURE
M12.43 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Measure workpiece.
2. Determine dimensional deviations from blueprint specifications.
3. Determine cutting tool responsible for inaccuracy.
4. Identify tool offset number for cutting tool.
5. Enter amount of tool offset in either diameter or radius into tool tables.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.44 Execute emergency stop.

PERFORMANCE OBJECTIVE
P12.44 Given a CNC machine tool, control, operational manual, and CNC program, execute an emergency stop. All controls must be verified as inactive while the emergency stop button is activated, as specified in the operational manual.

PERFORMANCE MEASURE
M12.44 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Locate emergency stop button on machine and/or control.
2. Press emergency stop button.
3. Verify that controls are inactive by observing status lights.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.45 Activate automatic cycle mode.

PERFORMANCE OBJECTIVE
P12.45 Given access to a CNC machine, control, and operating manual, activate the automatic cycle mode. Machine must run entire program or execute program block-by-block without interruption or operator intervention, as specified by the operating manual. Demonstration should include finding the zero point for all axes, as necessary, verifying the program number, searching for a safe start-up location, and verifying automatic cycle mode.

PERFORMANCE MEASURE
M12.45 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Power up control.
2. Find the zero point for all axes, as necessary.
3. Verify program number.
4. Search for appropriate safe start-up location.
5. Set control to automatic cycle mode or single block mode according to manufacturer's operating guide.
6. Start cycle.
7. Verify automatic cycle made by observing control.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 107, 125, 225, 245

TASK / COMPETENCY
12.46 Interrupt automatic cycle mode manually.

PERFORMANCE OBJECTIVE
P12.46 Given access to a CNC machine, control, and manufacturer's operating manual, interrupt the automatic cycle mode manually as specified in the operating manual. Automatic cycle mode must be interrupted when stop button is activated.

PERFORMANCE MEASURE
M12.46 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Switch from automatic cycle mode to single block mode according to manufacturer's operating/ programming manual.
2. Activate feed hold on control.
3. Execute emergency stop (see Task 12.44).

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 125, 225, 245

TASK / COMPETENCY
12.47 Run segment of program.

PERFORMANCE MEASURE
P12.47 Given a CNC machine tool, control, and manufacturer's operating manual, run a segment of the program. Operator must be able to review program, returning to a safe start-up block or running program forward to a safe start-up block of the next machining sequence according to manufacturer's operating manual.

PERFORMANCE MEASURE
M12.47 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Turn power unit ON.
2. Search for program, using sequence search key or dial.
3. Locate safe start-up block number or page number desired.
4. Activate block-by-block mode.
5. Activate cycle start.

DUTY AREA
12. PROGRAMMING AND OPERATING COMPUTER NUMERICAL CONTROL (CNC) MACHINES

COURSE
Precision Machining Technology
MAC 125, 225, 245

TASK / COMPETENCY
12.48 Interpret operation-related screen messages.

PERFORMANCE OBJECTIVE
P12.48 Given access to a CNC machine, processor language, CRT screen, operator's manual, and format of machine's computer system commands, interpret the operator-related screen messages. The interpretation of operator advisory messages on display screen must result in the execution of defined commands for maintaining programmed machining operations and generating an acceptable quality workpiece as specified on blueprint.

PERFORMANCE MEASURE
M12.48 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. View CRT screen during program dry run.
2. Observe operator messages in a specific sequence of operations.
3. Follow procedures outlined in machine manual and/or programmer guide for executing commands when message appears during production of piece part.

DUTY AREA 13. WORKING WITH CAD-CAM SYSTEMS

13.1 Develop a computer model of a machining process.
13.2 Transfer a CNC program from computer to CNC machine, using a Distributive Numerical Control System.
13.3 Transfer a CAD file to a CAM system.

RELATED ACADEMIC STANDARDS OF LEARNING
(Based on 1995 SOLs)

MATH		TECHNICAL COMPETENCY
COM.4	The student will use operating system commands, which include creating a new file, opening an existing file, saving a file, making a printed copy (hard copy) of the file, and executing a program.	13.1
COM.8	The student will design and implement computer graphics, which will include topics appropriate for the available programming environment as well as student background. Students will use graphics as an end in itself, as an enhancement to other output, and as a vehicle for reinforcing programming techniques.	13.2, 13.3

DUTY AREA
13. WORKING WITH CAD-CAM SYSTEMS

COURSE
Precision Machining Technology
MAC 225

TASK / COMPETENCY
13.1 Develop a computer model of a machining process.

PERFORMANCE OBJECTIVE
P13.1 Given a CAM system and a mechanical drawing, develop a computer model of a machining process required to produce a workpiece. Demonstration must include drawing, editing, rescaling, and panning across the model, creating a job operations file, saving the model, and outputting machine codes from the model, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M13.1 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Draw lines and arcs and locate points on a computer.
2. Make changes to the model, using the graphics editing function.
3. Rescale the display larger and smaller.
4. Pan across model.
5. Create a job operations file.
6. Save model to proper location.
7. Output machine codes from the model.

DUTY AREA
13. WORKING WITH CAD-CAM SYSTEMS

COURSE
Precision Machining Technolog
MAC 107, 125, 225, 245

TASK / COMPETENCY
13.2 Transfer a CNC program from computer to CNC machine, using a Distributive Numerical Control System.

PERFORMANCE OBJECTIVE
P13.2 Given a computer with a CNC program, a CNC machine, and DNC software, transfer CNC program from computer to CNC machine, using a Distributive Numerical Control system. Files must be transferred with 100% accuracy in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M13.2 Demonstration, performed with 100% accuracy and rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Determine the types of files and directories used to store files.
2. Select machine to which to transfer the program.
3. Set up a file for downloading.
4. Download program to the machine.

DUTY AREA
13. WORKING WITH CAD-CAM SYSTEMS

COURSE
Precision Machining Technology
MAC 225

TASK / COMPETENCY
13.3 Transfer a CAD file to a CAM system.

PERFORMANCE OBJECTIVE
P13.3 Given access to CAD/CAM equipment and software, transfer a CAD drawing file to a CAM system. Files must be transferred with 100% accuracy, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M13.3 Demonstration, performed with 100% accuracy and rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Determine the types of files and directories used to store files.
2. Determine the types of common graphics exchange formats, and select the appropriate format to be used.
3. Set up file for transfer.
4. Transfer file.

DUTY AREA 14. MAINTAINING MACHINES AND TOOLS

14.1 Inspect and change drive pulleys or belts.
14.2 Inspect and remove, replace, or adjust machine guards.
14.3 Replace and adjust machine parts.
14.4 Inspect and repair hand tools.
14.5 Perform preventive maintenance on a lathe.
14.6 Perform preventive maintenance on a milling machine.
14.7 Perform maintenance on a drill press.
14.8 Perform maintenance on a grinder.
14.9 Perform maintenance on a power saw.
14.10 Perform maintenance on an arbor press.
14.11 Perform maintenance on a hydraulic press.
14.12 Clean and lubricate a vise.
14.13 Install, inspect, level, and fasten down machines.
14.14 Clean and store hand tools, cutters, fixtures, jigs, and attachments.
14.15 Store grinding wheels.
14.16 Prepare and store precision tools.
14.17 Dispose of scrap metal, chips, shavings, trash, and waste materials.
14.18 Scrape and paint machines.

RELATED ACADEMIC STANDARDS OF LEARNING
(Based on 1995 SOLs)

MATH		TECHNICAL COMPETENCY
CH.1	The student will investigate and understand that experiments in which variables are measured, analyzed, and evaluated, produce observations and verifiable data.	14.3

DUTY AREA
14. MAINTAINING MACHINES AND TOOLS

COURSE
Precision Machining Technology
MAC 151

TASK / COMPETENCY
14.1 Inspect and change drive pulleys or belts.

PERFORMANCE OBJECTIVE
P14.1 Given an assortment of pulleys and belts, wrenches, pulley puller, hand tools, appropriate measurement instruments, *Machinery's Handbook*, and appropriate repair or maintenance manual, inspect and change drive pulleys or belts as necessary, according to the repair or maintenance manual standards. Demonstration should include use of various hand tools, selection and replacement of tools, alignment and fitting of replacement parts, use of lubricants, tracing a power train, and selecting speeds, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M14.1 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate use of an assortment of hand tools.
2. Identify cleaning and disassembly procedures.
3. Demonstrate selection and replacement of tools.
4. Demonstrate alignment and fitting of replacement parts.
5. Identify appropriate lubricants and demonstrate their use.
6. Identify the type of belts by shape.
7. Identify the size of belt by the code number.
8. Demonstrate tracing a power train and selecting speeds.
9. Identify the drive line and drive pulleys.
10. Interpret applicable sections of the maintenance manual.

DUTY AREA
14. MAINTAINING MACHINES AND TOOLS

COURSE
Precision Machining Technology
MAC 106

TASK / COMPETENCY
14.2 Inspect and remove, replace, or adjust machine guards.

PERFORMANCE OBJECTIVE
P14.2 Given an operations and maintenance manual, appropriate hand tools, and appropriate measurement instruments, inspect and remove, replace, or adjust machine guards according to the manufacturer's specifications and in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M14.2 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate use of the maintenance manual in locating and removing the guards and safety devices.
2. Inspect, remove, and replace the damaged parts.
3. Demonstrate adjustment of guards according to the manufacturer's specifications.
4. Explain and demonstrate the safety needs for machine guards.

DUTY AREA
14. MAINTAINING MACHINES AND TOOLS

COURSE
Precision Machining Technology
MAC 106, 107, 125, 151, 225, 245

TASK / COMPETENCY
14.3 Replace and adjust machine parts.

PERFORMANCE OBJECTIVE
P14.3 Given a work order and job specifications, appropriate tools, equipment, measuring instruments, lubricants, and cleaning materials, replace and adjust the machine parts according to work order and job specifications and in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M14.3 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Inspect machine parts for wear.
2. Lubricate parts as needed.
3. Adjust parts as needed according to work order and job specifications.
4. Remove and replace damaged parts.
5. Demonstrate adjustment of new parts according to work order and job specifications.

DUTY AREA
14. MAINTAINING MACHINES AND TOOLS

COURSE
Precision Machining Technology
MAC 106, 151

TASK / COMPETENCY
14.4 Inspect and repair hand tools.

PERFORMANCE OBJECTIVE
P14.4 Given broken hand tools and job specifications or manufacturer's standards, inspect and repair the hand tools according to job specifications or manufacturer's standards and in accordance with instructor's guidelines. Demonstration should include estimating the cost of repair.

PERFORMANCE MEASURE
M14.4 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Inspect the hand tools.
2. Identify the damage.
3. Assess the repairability, and estimate the cost of repair.
4. Repair the hand tools.

DUTY AREA
14. MAINTAINING MACHINES AND TOOLS

COURSE
Precision Machining Technology I/II
(8539) (8540)
MAC 151

TASK / COMPETENCY
14.5 Perform preventive maintenance on a lathe.

PERFORMANCE OBJECTIVE
P14.5 Given access to a lathe, an operational manual or manufacturer's specifications, cleaner, lubricant, hand tools, and precision measurement instruments, perform preventive maintenance on the lathe according to the operational manual or manufacturer's specifications. Demonstration should include adjustment or removal of guards, belts, and pulleys, lubrication of all working parts, cleaning, adjustment of lathe by using a precision level, and checking bedways and alignment by using a dial indicator.

PERFORMANCE MEASURE
M14.5 Demonstrate, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate adjustment or removal of guards, belts, and pulleys necessary to repair or adjust lathe.
2. Locate and lubricate all of the lathe's working parts according to the operational manual.
3. Demonstrate the cleaning of a lathe.
4. Identify all of the major parts of an engine lathe.
5. Demonstrate use of a precision level in adjusting a lathe.
6. Demonstrate use of a dial indicator for checking bedways and alignment.

DUTY AREA
14. MAINTAINING MACHINES AND TOOLS

COURSE
Precision Machining Technology I/II
(8539) (8540)
MAC 151

TASK / COMPETENCY
14.6 Perform preventive maintenance on a milling machine.

PERFORMANCE OBJECTIVE
P14.6 Given access to a milling machine, an operational manual or manufacturer's specifications, cleaner, lubricant, hand tools, and precision measurement instruments, perform preventive maintenance on the milling machine according to operational manual or manufacturer's specifications. Demonstration should include lubrication of all moving parts, cleaning, adjustment of guards, belts, and moving parts, and checking bedways, gib tension, and alignment by using a dial indicator.

PERFORMANCE MEASURE
M14.6 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify the major parts of a mill.
2. Locate and lubricate all moving parts of the milling machine according to the operational manual.
3. Demonstrate the cleaning of a mill and its attachments.
4. Demonstrate adjustment of belts, guards, and moving parts.
5. Locate and identify the purpose of gibs and lockdowns.
6. Demonstrate use of a dial indicator for checking bedways, gib tension, and alignment.

DUTY AREA
14. MAINTAINING MACHINES AND TOOLS

COURSE
Precision Machining Technology I/II
(8539) (8540)
MAC 151

TASK / COMPETENCY
14.7 Perform maintenance on a drill press.

PERFORMANCE OBJECTIVE
P14.7 Given access to a drill press, a service manual, cleaner, and lubricant, perform maintenance on the drill press according to service manual specifications. Demonstration should include lubrication of all moving parts, cleaning, and adjustment of belts, guards, and moving parts, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M14.7 Demonstration, all items rated acceptable on instructor-provided checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify the major parts of the drill press.
2. Locate and lubricate all moving parts of the drill press according to the service manual.
3. Demonstrate techniques for cleaning the drill press.
4. Demonstrate the adjustment of belts, guards, and moving parts.

DUTY AREA
14. MAINTAINING MACHINES AND TOOLS

COURSE
Precision Machining Technology I/II
(8539) (8540)
MAC 151

TASK / COMPETENCY
14.8 Perform maintenance on a grinder.

PERFORMANCE OBJECTIVE
P14.8 Given access to a grinder, a *Machinery's Handbook*, manufacturer's specifications, cleaner, a rawhide mallet, and assorted hand tools, perform maintenance on the grinder. Demonstration should include inspecting for safe operating conditions; cleaning and lubricating the grinder according to the manufacturer's specifications; adjusting belts, guards, and moving parts; and removing, testing, and reinstalling the grinding wheel, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M14.8 Demonstration, all procedures rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Locate and lubricate all of the grinder's moving parts according to the operational manual.
2. Demonstrate cleaning techniques for a grinder.
3. Demonstrate the adjustment of belts, guards, and moving parts.
4. Remove grinding wheel and perform the ring test for flaws on the wheel.
5. Identify all safety precautions.
6. Replace and align, face, and dress the grinding wheel.

DUTY AREA
14. MAINTAINING MACHINES AND TOOLS

COURSE
Precision Machining Technology I/II
(8539) (8540)
MAC 151

TASK / COMPETENCY
14.9 Perform maintenance on power saws.

PERFORMANCE OBJECTIVE
P14.9 Given access to a power saw, manufacturer's operational manual, cleaner, lubricant, and a feeler gauge, perform maintenance on the power saw. Demonstration should include inspecting the saw for safe and correct operation, cleaning and lubricating the saw according to the manufacturer's specifications, using feeler gauge to adjust the band guide to allow a clearance of 0.001" to 0.002", mounting blade and adjusting tension, and determining the set and sharpness of blade, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M14.9 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify the major parts of power saws.
2. Demonstrate cleaning techniques for the power saw.
3. Locate and lubricate all of the saw's moving parts according to the operational manual.
4. Demonstrate blade replacement by mounting the blade and adjusting the tension.
5. Demonstrate use of a feeler gauge by adjusting the band guides.
6. Demonstrate method of determining the type of set and the sharpness of saw blades.

DUTY AREA
14. MAINTAINING MACHINES AND TOOLS

COURSE
Precision Machining Technology I/II
(8539) (8540)
MAC 151

TASK / COMPETENCY
14.10 Perform maintenance on an arbor press.

PERFORMANCE OBJECTIVE
P14.10 Given access to an arbor press, manufacturer's maintenance manual, lubricants, oil can, and grease gun, perform maintenance on the press. Demonstration should include inspecting for safe operating conditions, cleaning and lubricating the press according to manufacturer's specifications, checking all parts for cracks and other flaws, and replacing damaged parts, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M14.10 Demonstration, all procedures rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify the major parts of an arbor press, and explain their functions.
2. Demonstrate safety inspection by checking all moving parts according to the operational manual.
3. Inspect parts for cracks and other flaws.
4. Replace any damaged parts.
5. Demonstrate selection and use of various lubricants.

DUTY AREA
14. MAINTAINING MACHINES AND TOOLS

COURSE
Precision Machining Technology I/II
(8539) (8540)
MAC 151

TASK / COMPETENCY
14.11 Perform maintenance on a hydraulic press.

PERFORMANCE OBJECTIVE
P14.11 Given access to a hydraulic press, an operational/maintenance manual, rubber gloves, brush, cleaning solvent, rags, lubricants, oil can, grease gun, and bucket, perform maintenance on the press. Demonstration should include inspecting for safe operating conditions, cleaning and lubricating the press in accordance with the manufacturer's specifications, inspecting fluid levels and travel clearance, checking system for leaks, and draining and refilling reservoirs, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M14.11 Demonstration, all procedures rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify the major parts of a hydraulic press and explain their functions.
2. Demonstrate safety inspection by checking the parts according to the operational manual.
3. Check for leaks in the hydraulic system.
4. Inspect hydraulic fluid levels and travel clearance.
5. Demonstrate cleaning techniques.
6. Locate and lubricate all moving parts.
7. Drain and refill reservoirs.
8. Identify hydraulic fluids by odor and color.

DUTY AREA
14. MAINTAINING MACHINES AND TOOLS

COURSE
Precision Machining Technology I/II
(8539) (8540)
MAC 151

TASK / COMPETENCY
14.12 Clean and lubricate a vise.

PERFORMANCE OBJECTIVE
P14.12 Given manufacturer's specifications, a vise, hand tools, lubricants, and cleaning materials, clean and lubricate a vise according to manufacturer's specifications. Demonstration must include identifying correct cleaning material and lubricant in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M14.12 Demonstration, rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Check for proper support and adjustments.
2. Demonstrate cleaning techniques.
3. Identify correct cleaning material and lubricant.

DUTY AREA
14. MAINTAINING MACHINES AND TOOLS

COURSE
Precision Machining Technology
MAC 151

TASK / COMPETENCY
14.13 Install, inspect, level, and fasten down machines.

PERFORMANCE OBJECTIVE
P14.13 Given access to a machine to be installed, installation equipment, operations and maintenance manual, shims, master level, wrenches, and an assortment of hand tools and fasteners, install, inspect, level, and fasten down the machine. The machine must be level according to the master level, and all procedures in the operations and maintenance manual must be followed.

PERFORMANCE MEASURE
M14.13 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Position the machine in the proper location.
2. Select the necessary tools and equipment for installing the machine.
3. Demonstrate use of leveling equipment.
4. Demonstrate use of fasteners.

DUTY AREA
14. MAINTAINING MACHINES AND TOOLS

COURSE
Precision Machining Technology I/II
(8539) (8540)
MAC 106, 107, 151, 205, 206, and 225

TASK / COMPETENCY
14.14 Clean and store hand tools, cutters, fixtures, jigs, and attachments.

PERFORMANCE OBJECTIVE
P14.14 Given cleaning fluids, rags, brushes, light oil, other lubricants, and storage facilities, clean and store hand tools, cutters, fixtures, jigs, and attachments. Demonstration must include selection of proper cleaning rags, fluids, and lubricants and selection of proper storage facilities, in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M14.14 Demonstration, all procedures rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Select the proper cleaning rags, fluids, and lubricants.
2. Demonstrate safe cleaning techniques for various tools and attachments.
3. Select the proper storage facilities for various tools and attachments.

DUTY AREA
14. MAINTAINING MACHINES AND TOOLS

COURSE
Precision Machining Technology I/II
(8539) (8540)
MAC 107

TASK / COMPETENCY
14.15 Store grinding wheels.

PERFORMANCE OBJECTIVE
P14.15 Given an assortment of grinding wheels, store the wheels in the proper place and order. Demonstration should include ring testing wheels for cracks and other flaws in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M14.15 Demonstration, all items rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate handling and storing procedures for different types of grinding wheels.
2. Demonstrate techniques for ring testing wheels for cracks and other flaws.

DUTY AREA
14. MAINTAINING MACHINES AND TOOLS

COURSE
Precision Machining Technology I/II
(8539) (8540)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
14.16 Prepare and store precision tools.

PERFORMANCE OBJECTIVE
P14.16 Given several precision tools, clean rags, tool and instrument oil, rust preventive, and an appropriate storage case, prepare and store precision tools according to instructor's guidelines. Demonstration must include cleaning, oiling, disassembly, and storage techniques.

PERFORMANCE MEASURE
M14.16 Demonstration, all procedures rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate cleaning and oiling techniques for precision tools.
2. Demonstrate disassembly and storage techniques for precision tools.

DUTY AREA
14. MAINTAINING MACHINES AND TOOLS

COURSE
Precision Machining Technology I/II
(8539) (8540)
MAC 106, 107, 205, 206, 225

TASK / COMPETENCY
14.17 Dispose of scrap metal, chips, shavings, trash, and waste materials.

PERFORMANCE OBJECTIVE
P14.17 Given cleaning materials, supplies, brushes, and labeled containers, dispose of scrap metal, chips, shavings, trash, and waste material, in accordance with instructors guidelines. Metals must be identified according to group and classification and placed in designated containers.

PERFORMANCE MEASURE
M14.17 Demonstration, all procedure rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify metals according to group and classification.
2. Demonstrate safe handling of chips, waste, and scraps.
3. Place chips, waste, and scraps in designated containers.

DUTY AREA
14. MAINTAINING MACHINES AND TOOLS

COURSE
Precision Machining Technology
MAC 151

TASK / COMPETENCY
14.18 Scrape and paint machines.

PERFORMANCE OBJECTIVE
P14.18 Given a machine to be painted, paint, paint brushes, paint sticks, spray paint primer, sandpaper. steel wool, scraper, masking tape, and cover cloth, scrape and paint the machines according to . . steps in the *Occupational Safety and Health Administration* (OSHA) *Guide.* Demonstration should include preparing surfaces for painting, covering or masking areas not to be painted, applying primer and finish paints, and cleaning up materials and area.

PERFORMANCE MEASURE
M14.18 Demonstration, all steps rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify the paint to be used.
2. Clean, sand, and/or scrape surfaces for painting.
3. Cover or mask parts not to be painted.
4. Demonstrate use of spray paint primer.
5. Apply the finish paint.
6. Clean and store materials.
7. Clean up painting area.

DUTY AREA 15. COMMUNICATING ON THE JOB

15.1 Demonstrate effective listening skills.
15.2 Demonstrate various modes of on-the-job communication.
15.3 Demonstrate public speaking ability.
15.4 Lead an informal meeting.
15.5 Write a technical report.
15.6 Write a clear set of directions.
15.7 Demonstrate the team approach to solving on-the-job problems.

RELATED ACADEMIC STANDARDS OF LEARNING
(Based on 1995 SOLs)

LANGUAGE ARTS		TECHNICAL COMPETENCY
10.1	The student will participate in and report small-group learning activities.	15.1-15.4, 15.7
10.2	The student will critique oral reports of small-group learning activities.	15.1-15.4, 15.7
10.4	The student will read and interpret printed consumer materials.	15.5
10.7	The student will develop a variety of writings with an emphasis on exposition.	15.5, 15.6, 15.7
10.8	The student will critique professional and peer writing.	15.3, 15.7
10.9	The student will use writing to interpret, analyze, and evaluate ideas.	15.1-15.7
10.10	The student will collect, evaluate, and organize information.	15.5, 15.7
11.1	The student will make persuasive presentations.	15.1-15.3
11.2	The student will analyze and evaluate persuasive presentations.	15.1-15.3, 15.7
11.4	The student will read a variety of print material.	15.5-15.7
11.7	The student will write a variety of forms with an emphasis on persuasion.	15.3, 15.5, 15.6
11.8	The student will write, revise, and edit personal and business correspondence to a standard acceptable in the work place and higher education.	15.2, 15.7
11.9	The student will analyze, evaluate, synthesize, and organize information from a variety of sources into a documented paper dealing with a question, problem, or issue.	15.5
12.1	The student will make a 5-10 minute formal presentation.	15.1-15.3, 15.7
12.2	The student will evaluate formal presentations.	15.7
12.4	The student will read a variety of print material.	15.5, 15.7
12.7	The student will develop expository and technical writings.	15.5, 15.6
12.8	The student will write documented research papers.	15.8

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DUTY AREA
15. COMMUNICATING ON THE JOB

COURSE
Precision Machining Technology I/II
(8539) (8540)
MAC 106, 107, 205, 206, 225
ENG 101

TASK / COMPETENCY
15.1 Demonstrate effective listening skills.

PERFORMANCE OBJECTIVE
P15.1 Given guidelines on effective listening and a simulated situation involving a message between a sender and a receiver, demonstrate effective listening skills. Demonstration should include use of "body language" affecting communication and should be performed in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M15.1 Role-play activity, all items on an instructor-prepared checklist rated acceptable

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Define *communication.*
2. Relate listening skills to communication.
3. Identity barriers to effective listening.
4. Identify keys to effective listening.
5. Demonstrate how "body language" can affect communication.
6. Role play an exercise that illustrates effective listening skills.

DUTY AREA
15. COMMUNICATING ON THE JOB

COURSE
Precision Machining Technology I/II
(8539) (8540)
ENG 101

TASK / COMPETENCY
15.2 Demonstrate various modes of on-the-job communication.

PERFORMANCE OBJECTIVE
P15.2 Given descriptions of the various modes of communication and examples of the importance of effective communication on the job, demonstrate various modes of on-the-job communication. Demonstration should include techniques that improve communication and should be performed in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M15.2 Role-play activity, all items on instructor-prepared checklist rated acceptable

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify types of communication (oral, written, nonverbal).
2. Identify factors that affect communication (listening skills, self-concept, interruptions, distractions, eye contact).
3. Identify techniques that improve communication (asking questions, eye contact).

DUTY AREA
15. COMMUNICATING ON THE JOB

COURSE
Precision Machining Technology I/II
(8539) (8540)
SPD 110

TASK / COMPETENCY
15.3 Demonstrate public speaking ability.

PERFORMANCE OBJECTIVE
P15.3 Given a topic and access to research materials, demonstrate public speaking ability. Demonstration should include researching, writing and delivering a 2- to 3-minute speech in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M15.3 2- to 3-minute speech on a subject approved by instructor, all aspects rated acceptable on instructor-prepared checklist

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Choose a topic.
2. Narrow the topic.
3. Research information.
4. Outline topic in sequential order.
5. Write speech.
6. Practice delivery in front of mirror or small group.
7. Present speech to appropriate audience.
8. Participate in VICA speech contests.

DUTY AREA
15. COMMUNICATING ON THE JOB

COURSE
Precision Machining Technology I/II
(8539) (8540)
SPD 110

TASK / COMPETENCY
15.4 Lead an informal meeting.

PERFORMANCE OBJECTIVE
P15.4 Given a meeting topic and guidelines on conducting informal meetings, lead an informal meeting by developing an agenda, calling meeting to order, communicating purpose of meeting and role of participants, keeping participants on track, stimulating and terminating discussion, summarizing decisions, and adjourning meeting.

PERFORMANCE MEASURE
M15.4 Role-play activity, all items on instructor-prepared checklist rated acceptable

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Notify participants about meeting date and time.
2. Develop a written agenda.
3. Call meeting to order.
4. Communicate purpose of meeting and role of participants.
5. Keep participants on track.
6. Stimulate discussion.
7. Terminate discussion when necessary.
8. Summarize decisions of meeting.
9. Adjourn meeting.
10. Write necessary correspondence required by the meeting.

DUTY AREA
15. COMMUNICATING ON THE JOB

COURSE
Precision Machining Technology I/II
(8539) (8540)
ENG 101, IND 114

TASK / COMPETENCY
15.5 Write a technical report.

PERFORMANCE OBJECTIVE
P15.5 Given a topic and access to references, write a technical report. Report must meet instructor's specifications for length, style, and content.

PERFORMANCE MEASURE
M15.5 Student-produced report, all aspects rated acceptable based on instructor-prepared written evaluation scale

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. List the techniques used in technical writing.
2. Explain research techniques.
3. List basic steps in writing a report and the characteristics of each.
4. Explain procedure for notetaking.
5. Explain sequential organization of report.
6. Explain importance of proofreading and revision.
7. Explain procedure of bibliographical entries.
8. Explain importance of visual aids (graphs, charts) in clarifying report.

DUTY AREA
15. COMMUNICATING ON THE JOB

COURSE
Precision Machining Technology I/II
(8539) (8540)
MAC 106, 206, ENG 101

TASK / COMPETENCY
15.6 Write a clear set of directions.

PERFORMANCE OBJECTIVE
P15.6 Given a set of complex, work-related directions that are garbled, incomplete, and imprecise, write a clear set of directions. Directions must be clear and complete and in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M15.6 Student-produced directions, rated acceptable based on criteria specified in instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Obtain writing samples from industry, and analyze for completeness and precision.
2. Provide a set of basic work-environment directions that are unclear, and have students practice rewriting to acceptable standards.
3. Choose a machine/process related to the course, and write directions for its use, operation, repair/ execution.
4. Use drawings to clarify concepts.

DUTY AREA
15. COMMUNICATING ON THE JOB

COURSE
Precision Machining Technology I/II
(8539) (8540)
MAC 206

TASK / COMPETENCY
15.7 Demonstrate the team approach to solving on-the-job problems.

PERFORMANCE OBJECTIVE
P15.7 Given information on steps and strategies of team approach problem solving, demonstrate the team approach to solving on-the-job problems by participating in small group problem-solving activities. Demonstration should be performed in accordance with instructor's guidelines.

PERFORMANCE MEASURE
M15.7 Small group problem-solving demonstration, rated acceptable based on criteria specified in instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain the concepts of the team approach.
2. Divide class into small teams and provide a meeting location for each team.
3. Identify the problem to be solved, including objectives to be met.
4. Provide appropriate background information to the teams.
5. Identify steps involved in solving the problem.
6. Present oral report.

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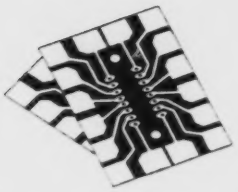
TASK ANALYSES

ENGINEERING, TRADE, AND TECHNICAL CLUSTER



Electronics Technology

A COMPETENCY-BASED CURRICULUM GUIDE

DEVELOPED BY

Crossroads Educational Consortium
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Carroll County Public Schools
Grayson County Public Schools
Smyth County Public Schools
Wythe County Public Schools
Galax City Schools
Wytheville Community College

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OCCUPATIONAL ANALYSIS

Occupational Task List: Electronics Technology

A. PREPARING FOR INSTRUCTIONAL ACTIVITIES
- Identify course expectations.
- Identify job opportunities in electronics occupations.
- Identify electronics program skill requirements.
- Participate in VICA activities.
- Describe job requirements.
- Demonstrate characteristics of a good technician.

B. IDENTIFYING SAFETY PROCEDURES
- Perform personal and equipment safety procedures.
- Demonstrate first aid procedures for electric shock.
- Identify voltage risks.
- Demonstrate the care and use of hand tools.
- Identify high energy risks.
- Identify government safety regulations.

C. COMMUNICATING WITH OTHERS
- Interpret and follow instructions.
- Ask clear, concise questions.
- Give clear, concise answers.
- Use research skills.
- Interpret blueprints and specifications.
- Translate charts and graphs.
- Develop leadership and teamwork skills.
- Practice telephone etiquette.
- Read with comprehension manufacturers' service literature, parts catalogs, and manuals containing industry standards.
- Write technical reports and instructions.
- Communicate with groups of people.

D. PERFORMING MATHEMATICAL CALCULATIONS
- Convert English units to metric and metric units to English.
- Determine if solutions to mathematical problems are reasonable.
- Solve algebra problems.
- Construct graphs on coordinate planes.
- Use exponents and square roots.
- Solve trigonometric problems.
- Convert electrical system units.

E. USING TEST EQUIPMENT
- Use digital and analog voltmeters, ammeters, and ohmmeters.
- Use AF signal generators.
- Use RF signal generators.
- Use oscilloscopes.
- Use pulse generators.
- Use logic analyzers.
- Use spectrum analyzer.
- Calibrate test equipment.

F. APPLYING DC FUNDAMENTALS

Identify and apply resistors and capacitors.
Use Ohm's law formula.
Use Watt's law formula.
Measure resistance, current, and voltage drop in DC circuits.
Analyze series circuit characteristics.
Analyze parallel circuit characteristics.
Analyze series-parallel circuit characteristics.
Analyze loaded and unloaded resistive voltage divider circuits.
Analyze DC circuits, using Kirchhoff's law.
Identify types of batteries and cells.
Troubleshoot series, parallel, and combination circuits.
Determine resistance and tolerance, using color codes.
Determine the magnetic properties of a circuit or component.
Use Thevenin's and Norton's theorems.
Analyze bridge circuits.
Analyze DC circuits, using mesh and nodal analysis.
Use maximum power transfer theorem (DC).

G. ANALYZING AC CIRCUITS

Determine current, voltage, and impedance in *RL*, *RC*, and *RLC* circuits.
Explain transformer operation.
Measure resistance, current, and voltage drop in an AC resistive circuit.
Analyze filter circuits.
Determine resonant frequencies in *LC* circuits.
Use maximum power transfer theorem (AC).
Demonstrate power factor corrections.
Analyze *RC*, *RL*, and *RLC* circuits, using transient analysis.
Use Thevenin's and Norton's theorems to analyze AC networks.
Design and construct a voltage regulator circuit.
Analyze resonance.

H. IDENTIFYING AND ANALYZING SOLID STATE CHARACTERISTICS

Analyze the operation of a PN diode.
Demonstrate uses of diodes.
Graph the characteristic curve of a zener diode.
Construct a half-wave rectifier circuit.
Construct a full-wave rectifier circuit.
Construct a voltage multiplier circuit.
Determine transistor characteristics and parameters.
Demonstrate the uses of transistors.
Analyze the uses of common solid state devices.
Troubleshoot transistor circuits.
Analyze the frequency response of an AC amplifier.
Analyze tuned class C amplifiers.
Troubleshoot an amplifier.
Analyze complementary symmetrical amplifiers.
Analyze and troubleshoot oscillator circuits.
Classify families of integrated circuits.

I. DEMONSTRATING FABRICATION TECHNIQUES
Demonstrate wire soldering techniques.
Demonstrate soldering techniques (components).
Construct wire harness (interface).
Prepare shielded wire and coaxial cables for installation.
Demonstrate proper handling techniques for static-sensitive components.
Develop electronic system layout (packaging).
Perform CAD layout techniques.

J. APPLYING DIGITAL LOGIC TECHNOLOGY
Identify digital circuitry, signals, and practices.
Identify logic symbols and Boolean expressions.
Construct truth tables for logic circuits.
Construct encoder and decoder circuits.
Describe sequential logic circuits.
Construct flip-flops, counter, and registers.
Explain digital memory circuits.
Troubleshoot combinational and sequential logic circuits.
Troubleshoot a complex logic circuit.
Design a seven-segment display circuit.
Troubleshoot digital-to-analog (D/A) and analog-to-digital (A/D) converter circuits.
Use Boolean expressions to solve complex digital circuitry.

K. APPLYING COMPUTER TECHNOLOGY
Identify microcomputer applications.
Interface peripheral equipment.
Identify characteristics of various informational storage systems.
Write and debug a software problem.
Troubleshoot a digital computer and peripherals.
Identify computer architecture.
Develop data collection applications.
Apply programmable controls.
Apply standard operating procedures.
Troubleshoot serial and parallel communications networks.
Construct a computer.
Write a program in a higher order language.

L. APPLYING ELECTRONIC COMMUNICATIONS TECHNOLOGY
Calculate decibel power gain and decibel voltage gain.
Troubleshoot opto-electronic devices.
Analyze impedance matching networks.
Identify types of transmitters.
Describe types of modulation.
Identify types of receivers.
Identify government regulations applicable to the operation of receivers and transmitters.
Troubleshoot transmitters and receivers.
Analyze microwave receivers and transmitters.
Construct receiver and transmitter circuits.
Design and construct antennas and transmission lines.
Analyze wave propagation.
Analyze frequency spectrums.

M. APPLYING INDUSTRIAL CONTROL SYSTEMS

Draw the 1-V characteristics of a SCR.
Troubleshoot feedback control systems.
Troubleshoot AC/DC drive systems.
Build manufacturing systems utilizing programmable logic controllers.

ELECTRONICS TRADE OCCUPATIONS

Apprentice
Electrical Technician
    Electrical Laboratory Technician
Electronics Technician
Electronic Production Line Maintenance Mechanic
Electronics Inspector
    Checker
    Component Parts Inspector
    Visual Inspector
    Line Inspector
Electronics Tester
    Component Tester
    Production Tester
    Quality Control Tester
    Testing Machine Operator
Audio-Video Repairer
    Audiovisual Aids Technician
Electrical-Instrument Repairer
    Instrument Maker
    Instrument Repairer
Public Address
    Electronic Sound Technician
    Public Address System Operator
Radio Interference Investigator (electronics)
    Radio Interference Troubleshooter
Radio Mechanic
Avionics Technician (aircraft-aerospace manufacturing; air transportation)
    Airplane Radio Tester
    Radio and Electrical Mechanic
    Radio Equipment Installer
    Radio Maintenance Repairer
Electronics Mechanic
    Communication Technician
    Electronics Equipment Mechanic
    Electronics Specialist
    Electronics System Mechanic
    Electronics Technician
Sound Technician
    Intercom Installer
    Intercom Servicer

PROGRAM DESIGN

Secondary Course Offerings

Electronics I (grade 11)
Electronics II (grade 12)
English 9 - 12
Algebra I and II
Probability and Statistics
Lab Sciences 9, 10, 11
World Studies
United States and Virginia History
United States and Virginia Governments
Health and Physical Education 9 and 10
Vocational Electives

Postsecondary Course Requirements (two years of courses at the community college level)

ENG 100:	Basic Occupational Communication
ENG 101:	Practical Writing I
SPD 115:	Small Group Communication
MTH 113-114:	Engineering Technical Math I & II
ECO 120:	Survey of Economics
PHY 201:	General College Physics I
PSY 120:	Human Relations
HLT 160:	Personal Health and Fitness
STD 100:	College Orientation
ETR 124:	Electronic Applications II
ELE 150:	AC and DC Circuit Fundamentals
EGR 127:	Introduction to Computer Programming
ETR 206:	Logic Circuits and Systems I
ETR 144:	Devices and Applications II
DRF 201:	Computer-Aided Drafting and Design I
ETR 261:	Microprocessor Applications I
ETR 241:	Electronic Communications I
ETR 237:	Industrial Electronics I
ELE 239:	Programmable Controllers
ETR 262:	Microprocessor Applications II
ETR 251:	Electronic Circuit Analysis I
ETR 211:	Electronics Diagnostics I
ETR 298:	Seminar and Projects in Electronics Technology
MEC 199:	Introduction to Basic CNC and CAM

DUTY AREA 1. PREPARING FOR INSTRUCTIONAL ACTIVITIES

1.1 Identify course expectations.
1.2 Identify job opportunities in electronics occupations.
1.3 Identify electronics program skill requirements.
1.4 Participate in VICA activities.
1.5 Describe job requirements.
1.6 Demonstrate characteristics of a good technician.

RELATED ACADEMIC STANDARDS OF LEARNING

(Based on 1995 SOLs)

ENGLISH		TECHNICAL COMPETENCY
10.8	The student will critique professional and peer writing: Apply knowledge of critical analysis to writing.	1.5
10.10	The student will collect, evaluate, and organize information.	1.2, 1.3, 1.5
11.9	The student will analyze, evaluate, synthesize, and organize information from a variety of sources.	1.2, 1.3, 1.6
12.1	The student will make a 5-10 minute formal oral presentation.	1.6
12.4	The student will read a variety of print materials.	1.2, 1.3, 1.5
SCIENCE		
PH.4	The student will investigate and understand how applications of physics affect the world. Key concepts include exploration of the roles and contributions of science and technology.	1.6

DUTY AREA
1. PREPARING FOR INSTRUCTIONAL ACTIVITIES

COURSE
All courses

TASK / COMPETENCY
1.1 Identify course expectations.

PERFORMANCE OBJECTIVE
P1.1 Given information about the course and the classroom management systems, together with copies of school, class, and laboratory rules, identify course expectations by stating course objectives, listing school, class, and laboratory rules, explaining responsibilities of the student and the teacher, and describing classroom and laboratory managment systems.

PERFORMANCE MEASURE
M1.1 Instructor-prepared assignment sheet, completed and rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. List school, class, and laboratory rules.
2. State course objectives.
3. Explain student and teacher responsibilities.
4. Describe classroom and laboratory management systems.
5. Participate in classroom/laboratory management systems by fulfilling assigned roles.

DUTY AREA
1. PREPARING FOR INSTRUCTIONAL ACTIVITIES

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
1.2 Identify job opportunities in electronics occupations.

PERFORMANCE OBJECTIVE
P1.2 Given access to trade bulletins or magazines, newspaper want ads, and other references, identify job opportunities in electronics occupations by describing jobs related to, duties of, employment outlook for, and educational requirements for electronics technicians.

PERFORMANCE MEASURE
M1.2 Instructor-prepared worksheet, all items rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify jobs related to the electronics technician field.
2. Explain duties of an Electronics Technician, as described by DOT 003.161-014, and of an Electronics Production-Line Maintenance Mechanic, as described by DOT 629.281-022.
3. Describe the employment outlook for electronics technicians.
4. Describe the educational requirements for electronics technicians.
5. Explain what is meant by entry-level employment.
6. Identify types of personal contacts that may be valuable when seeking employment.
7. Interpret newspaper employment ads.

DUTY AREA
1. PREPARING FOR INSTRUCTIONAL ACTIVITIES

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
1.3 Identify electronics program skill requirements.

PERFORMANCE OBJECTIVE
P1.3 Given information and appropriate instructions, identify the electronics program skill requirements necessary for successful completion. Identification should include necessary background skills, avenues for further education, and explanation of the need for communication and mathematics skills.

PERFORMANCE MEASURE
M1.3 Instructor-prepared worksheet, completed with at least 85% accuracy

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify background skills necessary for the study of electronics.
2. Identify colleges or universities that offer further education in electronics technology.
3. Describe the necessity for good communication skills.
4. Explain how mathematics applies to electronics.
5. Discuss application of the skills to real-life situations.

DUTY AREA
1. PREPARING FOR INSTRUCTIONAL ACTIVITIES

COURSE
Electronics I/II (8536/8537)

TASK / COMPETENCY
1.4 Participate in VICA activities.

PERFORMANCE OBJECTIVE
P1.4 Given VICA and instructor guidelines and information on parliamentary procedure, participate in VICA activities by selecting a committee to join, working on a VICA club project, or entering a VICA contest. Participation should include identifying advantages and responsibilities of membership, reciting motto and pledge, and identifying colors, emblem symbols, competitive events, activities, and club structure.

PERFORMANCE MEASURE
M1.4 Instructor-prepared worksheet, all items rated acceptable according to instructor's guidelines and VICA regulations

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify advantages and responsibilities of VICA membership.
2. Recite the VICA motto and pledge.
3. Identify VICA colors and emblem symbols.
4. Identify local, state, and national competitive events for electronics sponsored by VICA.
5. Identify VICA activities that benefit the community and the student.
6. Explain the VICA club structure.
7. Use parliamentary procedure.
8. Participate in an opening and closing ceremony.
9. View and discuss the filmstrip *VICA: Going All the Way* or the videotape *You're Number One with VICA*.

DUTY AREA
1. PREPARING FOR INSTRUCTIONAL ACTIVITIES

COURSE
Electronics II (8537)

TASK / COMPETENCY
1.5 Describe job requirements.

PERFORMANCE OBJECTIVE
P1.5 Given access to the *Dictionary of Occupational Titles* and other references, describe the job requirements of various electronics occupations by explaining and comparing the job responsibilities of various levels of electronics technicians and of various electronics occupations specified in the DOT.

PERFORMANCE MEASURE
M1.5 Instructor-prepared worksheet, all items rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain the content, purpose, and organization of the *Dictionary of Occupational Titles* (DOT) and *Occupational Outlook Handbook.*
2. Explain and compare the job responsibilities of various levels of electronics technicians such as apprentice, instrumentation technician, electronics-production-line technician, and electronics mechanic.
3. Based on research, describe the duties encompassed in various electronics occupations as specified in the DOT.

DUTY AREA
1. PREPARING FOR INSTRUCTIONAL ACTIVITIES

COURSE
Electronics I/II (8536/8537)

TASK / COMPETENCY
1.6 Demonstrate characteristics of a good technician.

PERFORMANCE OBJECTIVE
P1.6 Given information on the characteristics of a good electronics technician, demonstrate these characteristics in the classroom and laboratory. Student should cite examples of a positive work attitude, explain the importance of adhering to directions and developing loyalty to organization and supervisor, and discuss and demonstrate important work characteristics.

PERFORMANCE MEASURE
M1.6 Instructor-prepared checklist, all items rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Define *positive work attitude* and give examples of how it is demonstrated.
2. Explain the importance of adhering to written and verbal directions.
3. Identify the reasons for developing loyalty to an organization and supervisor.
4. Explain why an employer considers the following work characteristics important:
   - pays attention to detail
   - has good attendance
   - follows directions
   - accepts constructive criticism
   - is neat
   - is punctual
   - cooperates with others
   - is accurate
   - is honest
   - demonstrates good communication skills
   - assumes responsibility
   - is dependable
   - takes pride in workmanship

DUTY AREA 2. IDENTIFYING SAFETY PROCEDURES

2.1 Perform personal and equipment safety procedures.
2.2 Demonstrate first aid procedures for electric shock.
2.3 Identify voltage risks.
2.4 Demonstrate the care and use of hand tools.
2.5 Identify high energy risks.
2.6 Identify government safety regulations.

RELATED ACADEMIC STANDARDS OF LEARNING

(Based on 1995 SOLs)

		TECHNICAL COMPETENCY
ENGLISH		
10.4	The student will read and interpret printed consumer materials: Apply the information contained in labels, warnings, manuals, directions.	2.1, 2.4
11.9	The student will analyze, evaluate, synthesize, and organize information from a variety of sources.	2.1, 2.2, 2.4
12.1	The student will make a 5-10 minute formal oral presentation.	2.1, 2.4
12.8	The student will write documented research papers.	2.2
SCIENCE		
CH.1	The student will investigate and understand that experiments produce observations and verifiable data. Key concepts include safe use of chemicals and equipment.	2.1
PH.2	The student will investigate and understand how to analyze and interpret data. Key concepts include translation of a description of a physical problem into a mathematical statement in order to find a solution.	2.3

DUTY AREA
2. IDENTIFYING SAFETY PROCEDURES

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
2.1 Perform personal and equipment safety procedures.

PERFORMANCE OBJECTIVE
P2.1 Given personal safety equipment, equipment manuals, instructor's demonstration, and classroom and laboratory safety rules, perform personal and equipment safety procedures. Student must identify safety rules for hand and power tools, explain the use of various types of fire extinguishers and all safety equipment, describe accident reporting procedure and personal safety rules, and conduct safety inspections and tests.

PERFORMANCE MEASURE
M2.1 Instructor-prepared checklist, all items rated acceptable according to equipment manuals and instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify the federal safety color codes.
2. Identify specific safety rules for hand tools.
3. Outline power tool safety rules for specific pieces of equipment.
4. Explain the purpose and use of each type of fire extinguisher.
5. Explain the use of all safety equipment, including goggles, fireblankets, eyewash stations, etc.
6. State the accident reporting procedure.
7. List personal safety rules.
8. Explain procedures for maintaining a clean and orderly shop.
9. Post general and specific safety rules.
10. Carry out safety tests on equipment.
11. Conduct safety inspections.

DUTY AREA
2. IDENTIFYING SAFETY PROCEDURES

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
2.2 Demonstrate first aid procedures for electric shock.

PERFORMANCE OBJECTIVE
P2.2 Given instructor's demonstration and a simulated situation, demonstrate first aid procedures for electric shock. Demonstration should include identifying electric shock symptoms, following rescuer safety procedures, obtaining medical assistance, and practicing basic CPR and other electric shock treatment procedures.

PERFORMANCE MEASURE
M2.2 Instructor-prepared checklist, all items rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Describe the symptoms of electric shock.
2. List rescuer safety procedures.
3. Outline procedures for obtaining medical assistance.
4. Identify methods for treating victims of electric shock.
5. Describe the physiological effects of electrical currents on the human body.
6. Practice basic CPR procedures.

DUTY AREA
2. IDENTIFYING SAFETY PROCEDURES

COURSE
Electronics I/II (8536/8537)
Electronic Applications (ETR 124)

TASK / COMPETENCY
2.3 Identify voltage risks.

PERFORMANCE OBJECTIVE
P2.3 Given information on voltage risks associated with the laboratory and industrial and commercial electronic equipment, identify the voltage risks associated with each item of equipment. Student must discuss voltages that can cause harm, list equipment with voltage hazards, and discuss and demonstrate electrical safety rules and precautionary procedures to avoid shock.

PERFORMANCE MEASURE
M2.3 Instructor-prepared test, completed with at least 95% accuracy

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Review first aid procedures for electric shock (P2.2).
2. Discuss voltages that can cause harm or death.
3. List electrical and electronic safety rules.
4. Review the process of how and why current can pass through the body.
5. Review precautions to prevent current flow through the chest area.
6. Prepare a list of lab equipment with voltage hazards.
7. Prepare a list of commercial/industrial electronic equipment with voltage hazards.
8. List environmental conditions that increase the possibility of shock.
9. Discuss and demonstrate precautionary procedures to avoid electrical shock when using the laboratory and high-risk equipment.

DUTY AREA
2. IDENTIFYING SAFETY PROCEDURES

COURSE
Electronics I/II (8536/8537)

TASK / COMPETENCY
2.4 Demonstrate the care and use of hand tools.

PERFORMANCE OBJECTIVE
P2.4 Given information on the care and use of hand tools common to an electronics laboratory, demonstrate the care and use of each. Demonstration should include safety precautions applicable to hand tool use, operation of each tool, maintenance of each tool, and use of safety glasses.

PERFORMANCE MEASURE
M2.4 Demonstration, all items rated acceptable according to instructor-prepared guidelines and manufacturer's literature

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. List the hand tools and hand-held power tools to be used.
2. Discuss safety precautions when using hand tools.
3. Demonstrate the use of each tool.
4. Demonstrate the care of each tool.
5. Discuss regulations applicable to safety glasses.
6. Organize a safety committee to implement safety practices and suggest penalties for infractions (P3.7).

DUTY AREA
2. IDENTIFYING SAFETY PROCEDURES

COURSE
Electronics II (8537)

TASK / COMPETENCY
2.5 Identify high energy risks.

PERFORMANCE OBJECTIVE
P2.5 Given information pertaining to sources of harmful high energy, identify high energy risks. Identification should include the sources of and the OSHA regulations concerning high energy radiation, the physiological effects of exposure to high energy radiation and sound, and the first aid procedures for high energy injuries.

PERFORMANCE MEASURE
M2.5 Instructor-prepared test, completed with at least 95% accuracy

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Describe sources of high energy radiation.
2. Discuss OSHA regulations pertaining to high energy sources.
3. Describe the physiological effects of exposure to high energy radiation and sound.
4. Identify first aid procedures for high energy injuries.
5. Discuss means for detecting high energy hazards.

DUTY AREA
2. IDENTIFYING SAFETY PROCEDURES

COURSE
Electronics I/II (8536/8537)
Electronics Applications II (ETR 124)

TASK / COMPETENCY
2.6 Identify government safety regulations.

PERFORMANCE OBJECTIVE
P2.6 Given information on federal safety regulations pertaining to electrical/electronic equipment and devices, identify government safety regulations for electrical and electronic hazards. Identification should include the OSHA regulations concerning electrical/electronic equipment, the means for detecting electrical/electronic hazards, and the development of safety programs for a theoretical laboratory and a theoretical industrial situation.

PERFORMANCE MEASURE
M2.6 Instructor-prepared test, all items rated acceptable

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss OSHA regulations pertaining to industrial electrical/electronic equipment and devices.
2. Develop safety programs for a theoretical laboratory and a theoretical industrial situation.
3. Discuss means for detecting electrical/electronic hazards.

DUTY AREA 3. COMMUNICATING WITH OTHERS

3.1 Interpret and follow instructions.
3.2 Ask clear, concise questions.
3.3 Give clear, concise answers.
3.4 Use research skills.
3.5 Interpret blueprints and specifications.
3.6 Translate charts and graphs.
3.7 Develop leadership and teamwork skills.
3.8 Practice telephone etiquette.
3.9 Use manufacturers' service literature, parts catalogs, and manuals containing industry standards.
3.10 Write technical reports and instructions.
3.11 Present technical information to groups.

RELATED ACADEMIC STANDARDS OF LEARNING

(Based on 1995 SOLs)

		TECHNICAL COMPETENCY
ENGLISH		
10.1	The student will participate in and report small-group learning activities.	3.7
10.7	The student will develop a variety of writings with an emphasis on exposition. Edit final copies for correct use of language.	3.2, 3.3
10.10	The student will collect, evaluate, and organize information.	3.4, 3.5
11.1	The student will make persuasive presentations.	3.1
11.2	The student will analyze and evaluate persuasive presentations.	3.1
11.9	The student will analyze, evaluate, synthesize, and organize information from a variety of sources.	3.6, 3.7
12.4	The student will read a variety of print material.	3.1, 3.2, 3.6, 3.7
MATH		
A.10	The student will apply the laws of exponents to perform operations on expressions with integral exponents, using scientific notation when appropriate.	3.6
A.13	The student will estimate square roots to the nearest tenth and use a calculator to compute decimal approximations of radicals.	3.6
AII.2	The student will add, subtract, multiply, divide, and simplify rational expressions, including complex fractions.	3.6
SCIENCE		
BIO.1	The student will plan and conduct investigations in which observations of living things are recorded in the lab and in the field; hypotheses are formulated based on observations; variables are defined and investigations are designed to test hypotheses; conclusions are formed based on recorded quantitative and qualitative data; appropriate technology is used for gathering and analyzing data and communicating results; and research is used based on popular and scientific literature.	3.2, 3.3, 3.5
CH.1	The student will investigate and understand that experiments in which variables are measured, analyzed, and evaluated produce observations and verifiable data.	3.1

DUTY AREA
3. COMMUNICATING WITH OTHERS

COURSE
English 10 (1140)
Electronics I (8536)

TASK / COMPETENCY
3.1 Interpret and follow instructions.

PERFORMANCE OBJECTIVE
P3.1 Given three sets of instructions for tasks of varying degrees of complexity, interpret and follow instructions. Student must demonstrate effective listening and note-taking skills, the ability to see relationships and synthesize ideas, and the ability to complete each task correctly.

PERFORMANCE MEASURE
M3.1 Instructor-prepared checklist, all items rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. List effective listening skills.
2. Demonstrate effective note-taking skills.
3. Interpret instructions.
4. Demonstrate the ability to see relationships and synthesize ideas in order to draw reasonable conclusions.

DUTY AREA
3. COMMUNICATING WITH OTHERS

COURSE
English 10 (1140)
Electronics I (8536)

TASK / COMPETENCY
3.2 Ask clear, concise questions.

PERFORMANCE OBJECTIVE
P3.2 Given a complex transaction, ask clear, concise questions in order to clarify the issues involved. Questions must be designed to elicit information, arranged in a logical sequence, structured in grammatically correct form, and effective in fostering accurate conclusions about the transaction.

PERFORMANCE MEASURE
M3.2 Role-play activity, student participation rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. List effective listening skills.
2. Explain how to design questions which elicit information effectively.
3. Demonstrate arranging questions in logical sequence.
4. Demonstrate structuring questions in grammatically correct form.
5. Show precision in choice of words.
6. Show an ability to see relationships and synthesize effective questions to foster accurate conclusions.
7. Explain why verbal communication should be precise.

DUTY AREA
3. COMMUNICATING WITH OTHERS

COURSE
English 10 (1140)
Electronics I (8536)

TASK / COMPETENCY
3.3 Give clear, concise answers.

PERFORMANCE OBJECTIVE
P3.3 Given questions from a partner, give clear, concise answers to the questions by using, as needed, a combination of words, sketches, and demonstrations. Student must adapt wording of answer to questioner's language level, demonstrate four ways to give verbal feedback, and demonstrate use of facial expression, body language, and eye contact.

PERFORMANCE MEASURE
M3.3 Role-play activity, student participation accomplished within instructor's time limit and in accordance with instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Adapt wording to the questioner's language level.
2. Identify four ways to give verbal feedback.
3. Use sketches to clarify concepts.
4. Use demonstrations to clarify processes.
5. Explain the importance of facial expressions and body language.
6. Discuss the importance of eye contact and proper distance from the questioner.

DUTY AREA
3. COMMUNICATING WITH OTHERS

COURSE
English 10 (1140)
Electronics I/II (8536/8537)

TASK / COMPETENCY
3.4 Use research skills.

PERFORMANCE OBJECTIVE
P3.4 Given necessary instruction and access to sources, use research skills to gather information in an area pertaining to electronics. Research must result in a written report that is complete and accurate according to references, with all sources correctly documented.

PERFORMANCE MEASURE
M3.4 Written report, rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Suggest appropriate subjects for research (e.g., working conditions, salaries, entry-level requirements for a local industry, application of new developments in electronics).
2. List sources of technical information.
3. Explain the organization of a technical reference library.
4. Present research results in a seminar or "open forum."
5. Review documenting the sources of a written report.

DUTY AREA
3. COMMUNICATING WITH OTHERS

COURSE
Electronics I (8536)

TASK / COMPETENCY
3.5 Interpret blueprints and specifications.

PERFORMANCE OBJECTIVE
P3.5 Given two blueprints and accompanying specifications, one with an electrical and one with an electronic application, interpret the blueprints and specifications. Student must give a complete description of the application, identify all symbols and notations, and explain in general terms the provisions of the specifications.

PERFORMANCE MEASURE
M3.5 Instructor-prepared checklist, all items rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Describe the uses of blueprints.
2. Interpret blueprint symbols and notations.
3. Explain the provisions of a specification.
4. Write a specification for a simple electrical/electronic part or device.
5. Explain orientation in terms of blueprints.

DUTY AREA
3. COMMUNICATING WITH OTHERS

COURSE
Electronics I (8536)

TASK / COMPETENCY
3.6 Translate charts and graphs.

PERFORMANCE OBJECTIVE
P3.6 Given a number of charts and graphs appropriate to the electronics industry, translate charts and graphs by extracting data, constructing a data table, extracting specific data from a semi-logarithmic graph, depicting given data in chart and graph form, and demonstrating methods of titling charts and graphs.

PERFORMANCE MEASURE
M3.6 Written report, data depicted with at least 80% accuracy

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. List basic types of graphs and explain their uses.
2. Extract data from a graph and a chart and use it to construct a data table.
3. Explain the benefits of logarithmic and semi-logarithmic charts.
4. Extract specific data from a semi-logarithmic graph.
5. Depict given data in chart form and graph form.
6. Describe methods of titling charts and graphs.
7. Select transistors with correct "Beta" from transistor characteristics curve charts to meet a given specification.

DUTY AREA
3. COMMUNICATING WITH OTHERS

COURSE
English 10 (1140)
Electronics I (8536)

TASK / COMPETENCY
3.7 Develop leadership and teamwork skills.

PERFORMANCE OBJECTIVE
P3.7 Given a class organizational plan to include personnel duties, develop leadership and teamwork skills by participating in the organizational plan. Leadership and teamwork must result in classroom/ laboratory activities being effectively managed in accordance with the plan.

PERFORMANCE MEASURE
M3.7 Role-play activity, student participation rated acceptable according to the organizational plan

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss the need for classroom/laboratory organization.
2. Develop an organizational plan by group discussion to include personnel duties (e.g., safety committee chair, laboratory supervisor, tool and equipment supply person, social committee chair, etc.).
3. Explain the duties of each position in the above plan.
4. Fill each position on a rotating basis.
5. Conduct review discussion on success of plan and need for plan modifications.
6. Discuss the need for teamwork and cooperation.
7. Participate in VICA or other similar organizations.

DUTY AREA
3. COMMUNICATING WITH OTHERS

COURSE
Basic Occupational Communication (ENG 100)

TASK / COMPETENCY
3.8 Practice telephone etiquette.

PERFORMANCE OBJECTIVE
P3.8 Given established business standards for telephone etiquette and a simulated situation in which telephone use is required, practice telephone etiquette by making a call, answering the telephone, taking a message, giving and receiving information, handling a dissatisfied caller, and terminating a call. All items should be performed in accordance with established business standards.

PERFORMANCE MEASURE
M3.8 Instructor-prepared checklist, all items rated acceptable according to instructor's guidelines and established business standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain the elements of good telephone manners.
2. Answer telephone according to employer preference.
3. Take call for someone else.
4. Place call for someone else.
5. Take telephone message.
6. Give and receive information on the telephone.
7. Terminate a telephone call.
8. Demonstrate techniques for handling a difficult situation.

DUTY AREA
3. COMMUNICATING WITH OTHERS

COURSE
Electronics I/II (8536/8537)
Electronic Applications II (ETR 124)
Logic Circuits and Systems I (ETR 206)
Industrial Electronics I (ETR 237)

TASK / COMPETENCY
3.9 Use manufacturers' service literature, parts catalogs, and manuals containing industry standards.

PERFORMANCE OBJECTIVE
P3.9 Given the description of a malfunction in an electronic device, use manufacturers' service literature, parts catalogs, and manuals containing industry standards to determine the industry standards for the device, research the probable cause of the malfunction, and locate the part number of the defective part for a requisition. All malfunctions and part numbers must be identified, and replacement parts must meet industry standards.

PERFORMANCE MEASURE
M3.9 Demonstration, all steps completed according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. List the major sections of a service manual.
2. Identify electronic symbols.
3. List the probable cause of three specified malfunctions, using the service manual.
4. Explain what a schematic is.
5. Demonstrate how each part can be identified by referring to a parts list.
6. Demonstrate use of a cross reference catalog to locate suitable substitutes for parts.
7. Use the *Thomas Register* to select components and devices.

DUTY AREA
3. COMMUNICATING WITH OTHERS

COURSE
English 12 (1160)
Practical Writing I (ENG 101)

TASK / COMPETENCY
3.10 Write technical reports and instructions.

PERFORMANCE OBJECTIVE
P3.10 Given a selected topic and access to references, write a technical report and instructions that conform to instructor-provided specifications for length, form, and style. All other aspects of good report writing (e.g., footnotes, visual aids, bibliography, etc.) must be included.

PERFORMANCE MEASURE
M3.10 Instructor-prepared checklist, all items rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. List the basic expository techniques in technical writing.
2. Explain the relationship of research to writing instructions.
3. Explain the characteristics of an informational report.
4. Explain the characteristics of an analytical report.
5. List the basic steps in writing reports and instructions and explain the importance of each.
6. Explain the importance of and format for a topical outline.
7. Explain the use of visual aids in instructional material.
8. List the basic patterns for organizing aids in instructional material, reports, and instructional data.
9. List the basic structural elements of a technical report.
10. Explain the importance of and standard format for footnotes.
11. Explain the importance of and standard format for a bibliography.
12. Explain the importance of revising, editing, and proofreading.

DUTY AREA
3. COMMUNICATING WITH OTHERS

COURSE
Small Group Communication (SPD 115)

TASK / COMPETENCY
3.11 Present technical information to groups.

PERFORMANCE OBJECTIVE
P3.11 Given a simulated group situation and a body of technical information, present technical information to the group by using verbal, nonverbal, listening, and interaction skills to communicate effectively with the group.

PERFORMANCE MEASURE
M3.11 Demonstration, all items rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Study the communication process.
2. Develop speech-making skills for different situations through practice.
3. Practice using verbal and nonverbal skills.
4. Practice note-taking, composing, and research skills.
5. Develop listening skills through practice.
6. Interact in small groups.
7. Interview and be interviewed.

DUTY AREA 4. PERFORMING MATHEMATICAL CALCULATIONS

4.1 Convert English units to metric and metric units to English.
4.2 Determine if solutions to mathematical problems are reasonable.
4.3 Solve algebra problems.
4.4 Construct graphs on coordinate planes.
4.5 Use exponents and square roots.
4.6 Solve trigonometric problems.
4.7 Convert electrical system units.

RELATED ACADEMIC STANDARDS OF LEARNING
(Based on 1995 SOLs)

MATH		TECHNICAL COMPETENCY
A.1	The student will solve linear equations and inequalities in one variable, solve literal equations (formulas) for a given variable, and apply these skills to solve practical problems.	4.2, 4.3, 4.5, 4.6
A.2	The student will represent verbal quantitative situations algebraically and evaluate these expressions for given replacement values of the variables.	4.3, 4.6
A.3	The student will justify steps used in simplifying expressions and solving equations and inequalities. Justification will include the use of concrete objects, pictorial representations, and the properties of real numbers.	4.3, 4.6
A.7	The student will determine the slope of a line when given an equation of the line, the graph of the line, or two points on the line.	4.3, 4.6
A.9	The student will solve systems of two linear equations in two variables, both algebraically and graphically, and apply these techniques to solve practical problems.	4.3, 4.6
A.10	The student will apply the laws of exponents to perform operations on expressions with integral exponents, using scientific notation when appropriate.	4.3, 4.5, 4.6
A.11	The student will add, subtract, and multiply polynomials and divide polynomials with monomial divisors, using concrete objects, pictorial representations, and algebraic manipulations.	4.3, 4.5, 4.6
A.12	The student will factor completely first- and second-degree binomials and trinomials in one or two variables.	4.3, 4.6
A.13	The student will estimate square roots to the nearest tenth and use a calculator to compute decimal approximations of radicals.	4.3, 4.5, 4.6
A.14	The student will solve quadratic equations in one variable both algebraically and graphically.	4.3, 4.5, 4.6
AII.2	The student will add, subtract, multiply, divide, and simplify rational expressions, including complex fractions.	4.3, 4.5, 4.6
AII.7	The student will solve equations containing rational expressions and equations containing radical expressions algebraically and graphically.	4.2, 4.3, 4.5, 4.6
G.1	The student will construct and judge the validity of a logical argument consisting of a set of premises and a conclusion.	4.2
G.6	The student, given information concerning the lengths of sides and/or measures of angles, will apply the triangle inequality properties to determine whether a triangle exists and to order sides and angles.	4.6

G.7	The student will solve practical problems involving right triangles by using the Pythagorean Theorem and its converse, properties of special right triangles, and right triangle trigonometry.	4.6

SCIENCE

PH.2	The student will investigate and understand how to analyze and interpret data. Key concepts include a description of a physical problem translated into a mathematical statement in order to find a solution.	4.3, 4.4, 4.6
PH.5	The student will investigate and understand the interrelationships among mass, distance, force, and time through mathematical and experimental processes.	4.3, 4.6

DUTY AREA
4. PERFORMING MATHEMATICAL CALCULATIONS

COURSE
Electronics I (8536)

TASK / COMPETENCY
4.1 Convert English units to metric and metric units to English.

PERFORMANCE OBJECTIVE
P4.1 Given conversion tables and equipment, convert English units to metric and metric units to English. Conversions must show formulas and calculations plainly.

PERFORMANCE MEASURE
M4.1 Instructor-prepared test, at least 90% of problems solved correctly

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Review the metric system.
2. List metric and English units used to designate units of weight, volume, linear measure, temperature, pressure, velocity, and acceleration.
3. Practice converting units of measure from one system to the other, using conversion tables.

DUTY AREA
4. PERFORMING MATHEMATICAL CALCULATIONS

COURSE
Electronics I (8536)

TASK / COMPETENCY
4.2 Determine if solutions to mathematical problems are reasonable.

PERFORMANCE OBJECTIVE
P4.2 Given mathematical problems and several suggested solutions for each, determine if solutions to problems are reasonable and select the best solution for each. Process should show conversion of word problems into mathematical formulas, substitution of word problem solutions back into original equations, and estimation of solutions by rounding off.

PERFORMANCE MEASURE
M4.2 Instructor-prepared worksheet, at least 90% of solutions rated reasonable

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss examples of word problems used by technical personnel.
2. Convert word problems into mathematical formulas.
3. Solve word problems with addition, subtraction, multiplication, and division.
4. Substitute the solutions to word problems back into the original equations to show that the solution is reasonable.
5. Estimate solutions by rounding off fractions and decimals to whole numbers and making approximations.

DUTY AREA
4. PERFORMING MATHEMATICAL CALCULATIONS

COURSE
Algebra I (3130)
Electronics I (8536)
Engineering Technical Mathematics I-II (MTH 113-114)

TASK / COMPETENCY
4.3 Solve algebra problems.

PERFORMANCE OBJECTIVE
P4.3 Given algebra problems, solve algebra problems by using mathematical operations to add, subtract, multiply, and divide algebraic expressions. Problems should include linear equations in one variable, systems of linear equations, factoring, linear inequalities, and quadratic equations.

PERFORMANCE MEASURE
M4.3 Instructor-prepared test, at least 80% of problems solved correctly

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss the relationship between algebra and arithmetic.
2. Perform calculations involving decimals, fractions, and whole numbers.
3. Add, subtract, multiply, and divide algebraic expressions.
4. Solve linear algebraic equations in one variable.
5. Solve systems of linear equations.
6. Describe factoring as a method to solve algebraic equations.
7. Describe and show solutions to quadratic equations.
8. Solve linear inequalities.
9. Discuss the application of algebra to industrial electronics.

DUTY AREA
4. PERFORMING MATHEMATICAL CALCULATIONS

COURSE
Electronics I (8536)
Engineering Technical Mathematics I-II (MTH 113-114)

TASK / COMPETENCY
4.4 Construct graphs on coordinate planes.

PERFORMANCE OBJECTIVE
P4.4 Given mathematical problems or sets of related data, construct graphs on coordinate planes. Graphs must include examples of both bar and line and must show coordinate systems and mathematical scales.

PERFORMANCE MEASURE
M4.4 Student-produced graphs, data graphed with at least 90% accuracy

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss the use of graphing in industrial applications.
2. Discuss the types of information applicable to line or bar graphs.
3. Discuss coordinate systems and the mathematical scales that may be used in graphing a set of data.
4. Show examples of types of graphs in common use.

DUTY AREA
4. PERFORMING MATHEMATICAL CALCULATIONS

COURSE
Algebra I (3130)
Electronics I (8536)
Engineering Technical Mathematics I-II (MTH 113-114)

TASK / COMPETENCY
4.5 Use exponents and square roots.

PERFORMANCE OBJECTIVE
P4.5 Given mathematical problems, use exponents and square roots. Calculations should include addition, subtraction, multiplication, and division of exponential numbers and of square roots.

PERFORMANCE MEASURE
M4.5 Instructor-prepared test, at least 80% of problems solved correctly

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Describe the use of exponents and powers in mathematical applications.
2. Demonstrate mathematical methods used in addition, subtraction, multiplication, and division of exponential numbers.
3. Describe the square root of perfect-square and non-perfect-square positive rational numbers.
4. Demonstrate mathematical methods used in addition, subtraction, multiplication, and division of square roots.
5. Discuss the application of algebra to industrial electronics.

DUTY AREA
4. PERFORMING MATHEMATICAL CALCULATIONS

COURSE
Electronics I (8536)
AC/DC Fundamentals (ELE 150)
Engineering Technical Mathematics I-II (MTH 113-114)

TASK / COMPETENCY
4.6 Solve trigonometric problems.

PERFORMANCE OBJECTIVE
P4.6 Given trigonometric problems, tables, and a calculator, solve trigonometric problems. Calculations should include use of the Laws of Sines and Cosines, solutions of right triangles, and applications of trigonometry to amplitude, period, phase shifts, and alternating current.

PERFORMANCE MEASURE
M4.6 Instructor-prepared test, at least 80% of problems solved correctly

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss the use of trigonometry in electricity.
2. Describe trigonometric functions and use of calculators or tables to determine trigonometric values for angles.
3. Show the use of trigonometry in solving right triangles.
4. Discuss and show solutions to applied trigonometric problems.
5. Use the Laws of Sines and Cosines to solve trigonometric problems.
6. Relate trigonometric functions to amplitude, period, and phase shifts.
7. Solve problems involving alternating current and electronic devices.

DUTY AREA
4. PERFORMING MATHEMATICAL CALCULATIONS

COURSE
Electronics I & II (8536/8537)

TASK / COMPETENCY
4.7 Convert electrical system units.

PERFORMANCE OBJECTIVE
P4.7 Given conversion tables and a calculator, convert electrical system units. Conversions must show formulas and calculations plainly.

PERFORMANCE MEASURE
M4.7 Instructor-prepared test, at least 80% of problems solved correctly

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss electrical system units and show the relationship among them.
2. Show examples of the conversion between electrical system units.
3. Demonstrate use of conversion tables.
4. Practice converting system units, using conversion tables and calculator.

DUTY AREA 5. USING TEST EQUIPMENT

5.1 Use digital and analog voltmeters, ammeters, and ohmmeters.
5.2 Use an AF signal generator.
5.3 Use an RF signal generator.
5.4 Use frequency measuring devices.
5.5 Use a pulse generator.
5.6 Use a logic analyzer.
5.7 Use a spectrum analyzer.
5.8 Calibrate test equipment.

RELATED ACADEMIC STANDARDS OF LEARNING

(Based on 1995 SOLs)

SCIENCE	TECHNICAL COMPETENCY
PH.4 The student will investigate and understand how applications of physics affect the world. Key concepts include exploration of the roles and contributions of science and technology.	5.3

DUTY AREA
5. USING BASIC TEST EQUIPMENT

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
5.1 Use digital and analog voltmeters, ammeters, and ohmmeters.

PERFORMANCE OBJECTIVE
P5.1 Given necessary meters, use digital and analog voltmeters, ammeters, and ohmmeters. Meters must be connected safely and read correctly.

PERFORMANCE MEASURE
M5.1 Demonstration, readings within 10% of those obtained by instructor and procedure rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain the advantages and disadvantages of analog and digital meters.
2. Identify uses for digital and analog meters.
3. Explain the problems caused by improperly connected and incorrectly read meters.
4. Names two general types of meters.
5. Identify which meters are used for measuring current, voltage, and resistance.
6. Name three units of current measurement and names of meters used to measure each.
7. Names four units of voltage measurement and names of meters used to measure each.
8. Explain how a meter measures resistance.
9. List all safety precautions related to meter usage.

DUTY AREA
5. USING BASIC TEST EQUIPMENT

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
5.2 Use an AF signal generator.

PERFORMANCE OBJECTIVE
P5.2 Given necessary equipment, use an AF signal generator by connecting it and operating the controls. The generator must be connected, adjusted, and operated according to instructor-provided guidelines.

PERFORMANCE MEASURE
M5.2 Demonstration, all items rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Define signal generator.
2. Describe three basic types of signal-output generators.
3. Describe the two basic types of waveforms.
4. Discuss uses of AF signal generators.
5. Set up and operate an unmodulated AF signal generator.

DUTY AREA
5. USING BASIC TEST EQUIPMENT

COURSE
Electronics I/II (8536/8537)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
5.3 Use an RF signal generator.

PERFORMANCE OBJECTIVE
P5.3 Given necessary equipment, use an RF signal generator. The generator must be connected, adjusted, and operated according to instructor-provided guidelines.

PERFORMANCE MEASURE
M5.3 Demonstration, all items rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss the differences between AF and RF signal generators.
2. Discuss uses of RF signal generators.
3. Demonstrate matching of impedance output to input.
4. Connect an RF signal generator and adjust it to a specified frequency.

DUTY AREA
5. USING BASIC TEST EQUIPMENT

COURSE
Electronics I/II (8536/8537)
Electronic Communications I (ETR 241)

TASK / COMPETENCY
5.4 Use frequency measuring devices.

PERFORMANCE OBJECTIVE
P5.4 Given necessary equipment, use frequency measuring devices by connecting the devices, adjusting the controls, and reading the voltage/frequency in accordance with instructor's guidelines. Oscilloscope readings must be within 10% of the instructor's readings, and frequencies must be within ± 10% accuracy for wavemeter and within ± .01% for all others.

PERFORMANCE MEASURE
M5.4 Demonstration rated acceptable according to instructor's guidelines, oscilloscope readings within 10% of the instructor's readings and frequencies within ± 10% accuracy for wavemeter and within ± .01% for all others

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Name the basic parts of the oscilloscope.
2. Describe the purpose of each part of the oscilloscope.
3. Name four types of oscilloscope measurements.
4. Explain the function of each control on the oscilloscope.
5. Describe safety precautions to be observed before and during operation of the oscilloscope.
6. Demonstrate various applications of the oscilloscope.
7. Use an isolation transformer.
8. Discuss the theory of operation of different types of frequency measuring devices.
9. Demonstrate the connection and use of different types of frequency measuring devices.
10. Demonstrate precautions to protect frequency measuring devices.
11. List the limitations of each frequency measuring device.
12. Use each frequency measuring device to measure at least three different unknown frequencies.

DUTY AREA
5. USING BASIC TEST EQUIPMENT

COURSE
Electronics II (8537)
Logic Circuits and Systems I (ETR 206)

TASK / COMPETENCY
5.5 Use a pulse generator.

PERFORMANCE OBJECTIVE
P5.5 Given the necessary equipment and a set of conditions, use a pulse generator to meet all specified conditions. Generator must be connected to oscilloscope and load. Problems associated with ringing, poor rise or fall times, and pulse droop or sag must be addressed.

PERFORMANCE MEASURE
M5.5 Demonstration, all items rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate the operation and use of a pulse generator.
2. Connect oscilloscope, load, and pulse generator.
3. Set pulse generator to several different outputs, and use oscilloscope to verify the settings.
4. Discuss the problems indicated by ringing, poor rise and fall times, and pulse droop or sag.

DUTY AREA
5. USING BASIC TEST EQUIPMENT

COURSE
Electronics II (8537)
Logic Circuits and Systems I (ETR 206)

TASK / COMPETENCY
5.6 Use a logic analyzer.

PERFORMANCE OBJECTIVE
P5.6 Given necessary equipment, use a logic analyzer. Analyzer must be connected to the computer to display rational digital waveforms, connections must be according to manufacturer's instructions, and data must be acquired and displayed in both state and dissembled formats.

PERFORMANCE MEASURE
M5.6 Demonstration, all items rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss the operation of a logic analyzer.
2. Demonstrate interconnections between logic analyzer and digital equipment/computers.
3. Demonstrate logic analyzer triggering conditions and trigger-condition setup.
4. Demonstrate using logic analyzer and computer to acquire data, and display the data in both state and dissembled formats.

DUTY AREA
5. USING BASIC TEST EQUIPMENT

COURSE
Electronic Communications I (ETR 241)

TASK / COMPETENCY
5.7 Use a spectrum analyzer.

PERFORMANCE OBJECTIVE
P5.7 Given a spectrum analyzer, AM signal generator, FM signal generator, appropriate loads, and interconnecting cables, use a spectrum analyzer. AM and FM signal generators must be connected to the spectrum analyzer to display both signals in accordance with the spectrum analyzer's instruction manual.

PERFORMANCE MEASURE
M5.7 Demonstration, all items rated acceptable according to instructor's guidelines and in accordance with the spectrum analyzer's instruction manual

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain operation of spectrum analyzers.
2. Use signal generators (P5.2 and P5.3).
3. Demonstrate use of a spectrum analyzer.
4. Describe safety practices to protect the spectrum analyzer.
5. Display both AM and FM signals on a spectrum analyzer to view sidebands on total spectrum.

DUTY AREA
5. USING BASIC TEST EQUIPMENT

COURSE
Industrial Electronics I (ETR 237)

TASK / COMPETENCY
5.8 Calibrate test equipment.

PERFORMANCE OBJECTIVE
P5.8 Given a VOM, frequency counter, RF signal generator, oscilloscope, and appropriate interconnecting cables and standards, calibrate test equipment. Each piece of equipment must be calibrated in accordance with the manufacturer's instructions traceable to the National Bureau of Standards (NBS).

PERFORMANCE MEASURE
M5.8 Demonstration, all items rated acceptable according to instructor's guidelines and in accordance with manufacturer's standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss necessity for calibration and transfer standards.
2. Demonstrate the calibration of a VOM, a frequency counter, a signal generator, and an oscilloscope.
3. Calibrate a VOM and a frequency counter.

DUTY AREA 6. APPLYING DC FUNDAMENTALS

6.1 Identify and apply resistors and capacitors.
6.2 Use Ohm's law formula.
6.3 Use Watt's law formula.
6.4 Measure resistance, current, and voltage drop in a CD circuit.
6.5 Analyze series circuit characteristics.
6.6 Analyze parallel circuit characteristics.
6.7 Analyze series-parallel circuit characteristics.
6.8 Analyze loaded and unloaded resistive voltage divider circuits.
6.9 Analyze DC circuits, using Kirchhoff's law.
6.10 Identify types of batteries and cells.
6.11 Troubleshoot series, parallel, and combination circuits.
6.12 Determine resistance and tolerance, using color codes.
6.13 Determine the magnetic properties of a circuit or component.
6.14 Use Thevenin's and Norton's theorems.
6.15 Analyze bridge circuits.
6.16 Analyze DC circuits, using mesh and nodal analysis.
6.17 Use maximum power transfer theorem (DC).

RELATED ACADEMIC STANDARDS OF LEARNING

(Based on 1995 SOLs)

		TECHNICAL COMPETENCY
ENGLISH		
12.4	The student will read a variety of print material.	6.10
MATH		
A.1	The student will solve linear equations and inequalities in one variable, solve literal equations (formulas) for a given variable, and apply these skills to solve practical problems.	6.2, 6.3, 6.5, 6.6, 6.7, 6.8, 6.9
AII.7	The student will solve equations containing rational expressions and equations containing radical expressions algebraically and graphically.	6.2, 6.3, 6.5, 6.6, 6.7, 6.8, 6.9
G.3	The student will solve practical problems involving complementary, supplementary, and congruent angles that include vertical angles, angles formed when parallel lines are cut by a transversal, and angles in polygons.	6.6
G.4	The student will use the relationships between angles formed by two lines cut by a transversal to determine if two lines are parallel and verify, using algebraic and coordinate methods as well as deductive proofs.	6.3
G.6	The student, given information concerning the lengths of sides and/or measures of angles, will apply the triangle inequality properties to determine whether a triangle exists and to order sides and angles.	6.3
G.7	The student will solve practical problems involving right triangles by using the Pythagorean Theorem and its converse, properties of special right triangles, and right triangle trigonometry.	6.3
SCIENCE		
PH.13	The student will investigate and understand how to diagram and construct basic electrical circuits and explain the function of various circuit components.	6.2, 6.5, 6.6, 6.12

DUTY AREA
6. APPLYING DC FUNDAMENTALS

COURSE
Electronics I (8536)

TASK / COMPETENCY
6.1 Identify and apply resistors and capacitors.

PERFORMANCE OBJECTIVE
P6.1 Given different types of resistors and capacitors, identify and apply resistors and capacitors. The type, value, schematic symbol, and application of each must be identified with at least 90% accuracy.

PERFORMANCE MEASURE
M6.1 Instructor-prepared test, completed with at least 90% accuracy

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Define
   a. *resistor*
   b. *fixed resistor*
   c. *variable resistor*
   d. *nonlinear resistor*
   e. *rheostat*
   f. *potentiometer.*
2. Discuss applications of each of the above.
3. Define *capacitor* and discuss types and applications of capacitors.
4. Draw the schematic symbols for
   a. *fixed R*
   b. *variable R*
   c. *potentiometer*
   d. *rheostat*
   e. *capacitor.*
5. Demonstrate reading and interpreting resistor and capacitor color codes.
6. Determine resistance and tolerance, using color codes (P6.12).

DUTY AREA
6. APPLYING DC FUNDAMENTALS

COURSE
Electronics I (8536)

TASK / COMPETENCY
6.2 Use Ohm's law formula.

PERFORMANCE OBJECTIVE
P6.2 Given Ohm's law and two of the three variables (voltage, current, or resistance) for five different simple circuits, use Ohm's law formula to solve for the third variable in each circuit. Student must define and state the unit of measure of current, voltage, and resistance, and all calculations must agree with those of the instructor.

PERFORMANCE MEASURE
M6.2 Instructor-prepared test, all calculations agree with those of the instructor

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Define *coulomb.*
2. Define *current* and state its unit of measure.
3. Define *voltage* and state its unit of measure.
4. Define *resistance* and state its unit of measure.
5. Explain the difference between conventional current and electron flow.
6. Solve Ohm's law formula for any one variable, given the other two variables.

DUTY AREA
6. APPLYING DC FUNDAMENTALS

COURSE
Electronics I (8536)

TASK / COMPETENCY
6.3 Use Watt's law formula.

PERFORMANCE OBJECTIVE
P6.3 Given the DC equations applicable to Watt's law, instruction on the relationships involved, and problems involving the DC application of Watt's law, use Watt's law formula. Student must define *power* and its unit of measure, explain why efficiency is a factor in computing horsepower, and demonstrate the use of the power triangle. All calculations must be completed with at least 80% accuracy.

PERFORMANCE MEASURE
M6.3 Instructor-prepared test, all calculations completed with at least 80% accuracy

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss the terminology related to power and wattage.
2. Demonstrate the use of the power triangle and its related equations.
3. Explain why efficiency is a factor in computing horsepower.
4. Explain the application of Watt's law.
5. Practice application of Watt's law to a number of problems.

DUTY AREA
6. APPLYING DC FUNDAMENTALS

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
6.4 Measure resistance, current, and voltage drop in a DC circuit.

PERFORMANCE OBJECTIVE
P6.4 Given a simple series DC circuit and the appropriate meters, measure the resistance of, current through, and voltage drop across each component of the circuit while observing proper meter connections and safety practices. Loading effects of a voltmeter and insertion effects of an ammeter must be explained. All measurements must be within 10% of the instructor's measurements.

PERFORMANCE MEASURE
M6.1 Demonstration, all measurements within 10% of instructor's measurements

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Use voltmeters, ammeters, and ohmmeters (P5.1).
2. Measure voltage, current, and resistance values at specified points on each of the voltage, current, and resistance ranges of a multimeter.
3. Connect a current meter and measure the direct current in a circuit.
4. Observe the effects of resistance in controlling current in a circuit.
5. Observe the effects of voltage in controlling current in a circuit.
6. Identify the necessary safety precautions for measuring voltage, current, and resistance in a circuit.
7. Explain loading effects of a voltmeter and insertion effects of an ammeter.

DUTY AREA
6. APPLYING DC FUNDAMENTALS

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
6.5 Analyze series circuit characteristics.

PERFORMANCE OBJECTIVE
P6.5 Given a functional series circuit, necessary formulas, and a multimeter, analyze series circuit characteristics. Student must prepare a schematic drawing of the circuit, determine polarity of the voltage drop across each resistor, use Kirchhoff's law, and demonstrate the characteristics of the circuit experimentally.

PERFORMANCE MEASURE
M6.5 Instructor-prepared test, all items completed and analyzed accurately

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Prepare a schematic drawing and label all components of a series circuit consisting of three resistors, an on-off switch, and a voltage source.
2. State rule for determining polarity of the voltage drop across each resistor in a series circuit.
3. Use Kirchhoff's law to prove that if $V_T = V_1 + V_2 + V_3$, then $R_T = R_1 + R_2 + R_3$.
4. Derive the formula $P_T = P_1 + P_2 + P_3$ from the fact that $V_T = V_1 + V_2 + V_3$.
5. Explain why the largest R in a series circuit dissipates the most power.
6. Demonstrate the characteristics of a series resistive circuit experimentally.
7. List the characteristics of a series resistive circuit.

DUTY AREA
6. APPLYING DC FUNDAMENTALS

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
6.6 Analyze parallel circuit characteristics.

PERFORMANCE OBJECTIVE
P6.6 Given a functional parallel circuit, necessary formulas, and a multimeter, analyze parallel circuit characteristics. Student must prepare a schematic drawing of the circuit, use Kirchhoff's law, and determine the total current and the total resistance in the circuit.

PERFORMANCE MEASURE
M6.6 Instructor-prepared test, all items completed and analyzed accurately

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Draw a schematic of a parallel circuit consisting of three resistors, an on-off switch, and a voltage source; label all components.
2. Use Kirchhoff's law to prove that if $1/R_T = 1/R_1 + 1/R_2$, then $R_T = (R_1 \times R_2)/(R_1 + R_2)$.
3. Connect three equal resistors to produce a combined equivalent resistance of one third the value of one resistor.
4. Explain why the current increases in the voltage source as more parallel branches are added to the circuit.
5. Explain why the total power equals the sum of the individual values of power in a series circuit or a parallel circuit.
6. Demonstrate experimentally that the total current I_T in a circuit containing resistors connected in parallel is (a) greater than the current in any branch and (b) equal to the sum of the currents.
7. Demonstrate experimentally that the total resistance R_T of resistors connected in parallel is given by the following formula: $1/R_T = 1/R_1 + 1/R_2 + 1/R_3 + \ldots$
8. Design and construct a parallel circuit that will meet specified voltage, current, and resistance requirements, and check, by measurements, the design parameters.

DUTY AREA
6. APPLYING DC FUNDAMENTALS

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
6.7 Analyze series-parallel circuit characteristics.

PERFORMANCE OBJECTIVE
P6.7 Given a functional series-parallel circuit, necessary formulas, and a multimeter, analyze series-parallel circuit characteristics. Student must draw a variety of series-parallel circuits, verify experimentally the law for total resistance R_T of a series-parallel combination of resistors, design a series-parallel network that will meet specified requirements, and solve problems for current, resistance, power, and voltage in series-parallel circuits.

PERFORMANCE MEASURE
M6.7 Instructor-prepared test, all items completed and analyzed accurately

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Prepare a schematic showing two resistors in parallel and in series with one resistor and a voltage source.
2. Reduce several series-parallel circuits to an equivalent series circuit containing only one resistor by redrawing the circuit each time two resistors are combined into one.
3. Draw a circuit that shows an example of both positive and negative voltages with respect to ground.
4. Verify experimentally the law for total resistance R_T of a series-parallel combination of resistors; verify that the voltage across each leg in a parallel circuit is the same as the total voltage across the parallel circuit.
5. Design a series-parallel network that will meet specified requirements.
6. Draw the schematic diagram of a Wheatstone bridge circuit as two series resistance strings connected in parallel, and label each resistor as either R_X, R_S, R_1, R_2.
7. Prove that when the Wheatstone bridge is at balance, there will be no current flow through the galvanometer.
8. Solve problems for branch current, total current, total resistance, total power supplied by the source, and voltage drops in a series-parallel circuit.

DUTY AREA
6. APPLYING DC FUNDAMENTALS

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
6.8 Analyze loaded and unloaded resistive voltage divider circuits.

PERFORMANCE OBJECTIVE
P6.8 Given a resistive voltage divider, analyze loaded and unloaded resistive voltage divider circuits. The effects of a load on the voltage divider must be determined by comparing the currents through and the voltage drops across each resistor, with and without a load.

PERFORMANCE MEASURE
M6.8 Instructor-prepared test, all analyzed results matching those of the instructor

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Use the proportional voltage method to calculate the voltage drop across each resistor in a series circuit containing three resistors.
2. Use the conductance formula $I_1 = G_1 \times I_T$ to calculate the branch current in a current divider G_T with three branches.
3. Define the following:
   a. *series voltage dividers*
   b. *parallel circuit dividers*
   c. *bleeder current.*
4. Design a loaded voltage divider circuit consisting of three series resistors with three different loads.
5. Confirm experimentally the general law for computing the voltage across each resistor in an unloaded fixed resistive voltage divider.
6. Construct the circuit designed in 4 above, and confirm, by measurements, the design parameters.

DUTY AREA
6. APPLYING DC FUNDAMENTALS

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
6.9 Analyze DC circuits, using Kirchhoff's law.

PERFORMANCE OBJECTIVE
P6.9 Given a schematic diagram of a DC series-parallel circuit that contains three branches and two generators, the values for each resistor, and the generator voltages, analyze DC circuits, using Kirchhoff's law. The analysis must find the voltage drop across each resistor, the current flow, and the current direction in each branch. All calculations must be within 10% of the instructor's calculations.

PERFORMANCE MEASURE
M6.9 Instructor-prepared test, all calculations within 10% of instructor's calculated values

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. State Kirchhoff's current law in two ways.
2. State Kirchhoff's voltage law in two ways.
3. Define a *node voltage.*
4. Solve several circuit problems by applying Kirchhoff's law.
5. Apply schematics and drawings.

DUTY AREA
6. APPLYING DC FUNDAMENTALS

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
6.10 Identify types of batteries and cells.

PERFORMANCE OBJECTIVE
P6.10 Given information pertaining to wet cell and dry cell batteries and examples of each, identify types of batteries and cells, including the fundamentals of construction, capabilities, limitations, maintenance procedures, and safety precautions with at least 85% accuracy.

PERFORMANCE MEASURE
M6.10 Instructor-prepared test, all items completed with at least 85% accuracy

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. State the purpose of the three parts of a cell.
2. Explain the differences between the two types of cells.
3. Outline the chemical process that occurs in primary and secondary cells.
4. Describe general maintenance procedures for batteries, including use of hydrometers, battery capacity, rating, and battery charging.
5. Describe all safety precautions associated with working on and around batteries.
6. Explain NiCad and lead-acid battery charging procedures.
7. Discuss types of batteries most suitable for several specific applications.
8. Explain why terminal voltage drops with increased load current.
9. Check wet and dry cell batteries for serviceability.

DUTY AREA
6. APPLYING DC FUNDAMENTALS

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
6.11 Troubleshoot series, parallel, and combination circuits.

PERFORMANCE OBJECTIVE
P6.11 Given circuit components, supplies, and a lab sheet, troubleshoot series, parallel, and combination circuits. Troubleshooting steps must include construction of series, parallel, and combination circuits in accordance with specifications on lab sheet, hypothetical calculations, operational test, verification of circuit operation by instructor, and identification and correction of any problem.

PERFORMANCE MEASURE
M6.11 Demonstration, all steps in accordance with instructor's guidelines and circuit operational

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Define *open, infinite, short circuit,* and *equivalent resistance.*
2. Explain series-parallel circuit characteristics (P6.7).
3. Determine current, voltage, resistance, and power.
4. Use a multimeter (P5.2).
5. Apply Ohm's law (P6.2).
6. Determine resistance value by color code (P6.12).
7. Compare hypothetical calculations to actual measured and computed values.

DUTY AREA
6. APPLYING DC FUNDAMENTALS

COURSE
Electronics I (8536)

TASK / COMPETENCY
6.12 Determine resistance and tolerance, using color codes.

PERFORMANCE OBJECTIVE
P6.12 Given a selection of color-coded resistors, determine the resistance and tolerance of each, using color codes. Demonstration must include defining the meaning and use of tolerances and reading color codes. All calculations must be at least 95% accurate.

PERFORMANCE MEASURE
M6.12 Demonstration, all items completed and calculated with at least 95% accuracy

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss and show examples of types of resistors that are color-coded.
2. Discuss the meaning and use of tolerances.
3. Practice reading color codes.

DUTY AREA
6. APPLYING DC FUNDAMENTALS

COURSE
Electronics I (8536)
Electronic Applications II(ETR 124)

TASK / COMPETENCY
6.13 Determine the magnetic properties of a circuit or component.

PERFORMANCE OBJECTIVE
P6.13 Given simple magnetic circuits and components of circuits, determine the magnetic properties of a circuit or component, including identification of poles, flux density, magnetic field intensity, and permeability. All calculations must be at least 80% accurate.

PERFORMANCE MEASURE
M6.13 Demonstration, all items completed and calculated with at least 80% accuracy

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain how magnetism occurs in a permanent magnet and in an electromagnet.
2. State the left hand rule.
3. Define the following terms: *magnetic field, flux, ampere-turn, diamagnetic, ferromagnetic, paramagnetic, flux density, magnetic field intensity, permeability, reluctance, hysteresis.*
4. Explain factors affecting the magnetizing force of magnetomotive force of an electromagnet.
5. Describe characteristics of a low voltage relay.

DUTY AREA
6. APPLYING DC FUNDAMENTALS

COURSE
Electronic Applications II (ETR 124)

TASK / COMPETENCY
6.14 Use Thevenin's and Norton's theorems.

PERFORMANCE OBJECTIVE
P6.14 Given a resistive circuit that has two voltage sources, the values of the voltage sources, the values of the resistors, and the load resistance R_L, use Thevenin's theorem to calculate V_{Th} and R_{Th}, Norton's theorem to calculate I_N and R_N, and use Thevenin-Norton conversion formulas to convert between the two equivalent forms of the circuit. All values must be calculated within 1% of the instructor's calculations.

PERFORMANCE MEASURE
M6.14 Instructor-prepared test, all values calculated within 1% of instructor's calculations

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Calculate the Thevenin equivalent voltage and series resistance for a given circuit.
2. Calculate the Norton equivalent current source and parallel resistance for a given circuit.
3. Using the conversion formulas, convert between Norton's and Thevenin's equivalent circuits.
4. Calculate the current through the load resistor of an unbalanced bridge circuit, using Thevenin's theorem.
5. Conduct an experiment to confirm the values V_{Th} and R_{Th} proposed by Thevenin's theorem in the solution of unbalanced bridge circuits.
6. Conduct an experiment to verify the values of I_N and R_N proposed by Norton's theorem in the solution of complex DC networks containing two voltage sources.
7. Explain why maximum power will be transferred to the load when $R_L = R_{Th}$.

DUTY AREA
6. APPLYING DC FUNDAMENTALS

COURSE
Electronic Applications II (ETR 124)

TASK / COMPETENCY
6.15 Analyze bridge circuits.

PERFORMANCE OBJECTIVE
P6.15 Given a schematic of a bridge circuit, the value of the voltage source, and the value of the resistors, analyze the bridge circuit. Analysis must include calculation of the voltage across and the current through the balance arm of the bridge, conversion of a delta network to wye network, and calculation of the voltage drop across the balance arm of a bridge network, using mesh and nodal analysis. All values must be calculated within 1% of the instructor's calculations.

PERFORMANCE MEASURE
M6.15 Instructor-prepared test, all values calculated within 1% of instructor's calculations

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Draw three bridge networks using three different forms.
2. Draw the schematic circuit for a tee or wye and a pi or delta network.
3. State the six formulas needed to convert from wye to delta and from delta to wye.
4. Convert a delta network to wye network, showing all calculations.
5. Use the delta-to-wye conversion method to calculate the total resistance of a bridge circuit.
6. Calculate the voltage drop across the balance arm of a bridge network, using mesh and nodal analysis.
7. Explain the difference between a balanced and an unbalanced bridge.

DUTY AREA
6. APPLYING DC FUNDAMENTALS

COURSE
Electronic Applications II (ETR 124)

TASK / COMPETENCY
6.16 Analyze DC circuits, using mesh and nodal analysis.

PERFORMANCE OBJECTIVE
P6.16 Given DC circuits containing several elements, analyze the DC circuits, using mesh and nodal analysis to obtain the voltages and currents in each circuit element. All calculated values must be in agreement with those of the instructor.

PERFORMANCE MEASURE
M6.16 Instructor-prepared test, all calculated values in agreement with those of the instructor

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Define *node, mesh, loop,* and *branch.*
2. State two forms of Kirchhoff's current law (KCL).
3. Given two equivalent forms of Kirchhoff's voltage law (KVL).
4. Identify the loops and meshes in a number of circuits.
5. Explain the terms of the equation $n = B - N + 1$.
6. List the steps to be followed to apply systematically the shortcut generalized procedure of mesh analysis.
7. Analyze a number of DC circuits, using mesh and nodal analysis and the shortcut procedure.

DUTY AREA
6. APPLYING DC FUNDAMENTALS

COURSE
Electronic Applications II (ETR 124)

TASK / COMPETENCY
6.17 Use maximum power transfer theorem (DC).

PERFORMANCE OBJECTIVE
P6.17 Given a fixed-impedance DC circuit, use the maximum power transfer theorem to calculate the maximum power that can be delivered. All calculations must be within 5% of instructor's calculations.

PERFORMANCE MEASURE
M6.17 Instructor-prepared test, all calculations within 5% of instructor's calculations

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Develop Thevenin equivalent circuits.
2. Discuss the development and application of the maximum power transfer theorem.
3. Construct a series circuit to verify the theorem.
4. Describe at least two industrial situations in which the theorem is applicable.

DUTY AREA 7. ANALYZING AC CIRCUITS

7.1 Determine current, voltage, and impedance in *RL*, *RC*, and *RLC* circuits.
7.2 Explain transformer operations.
7.3 Measure resistance, current, and voltage drop in an AC resistive circuit.
7.4 Analyze filter circuits.
7.5 Determine resonant frequencies in *LC* circuits.
7.6 Use maximum power transfer theorem (AC).
7.7 Demonstrate power factor corrections.
7.8 Analyze *RC*, *RL*, and *RLC* circuits, using transient analysis.
7.9 Use Thevenin's and Norton's theorems to analyze AC networks.
7.10 Design and construct a voltage regulator circuit.
7.11 Analyze resonance.

RELATED ACADEMIC STANDARDS OF LEARNING

(Based on 1995 SOLs)

		TECHNICAL COMPETENCY
ENGLISH		
11.9	The student will write, revise, and edit personal and business correspondence to a standard acceptable in the work place and higher education.	7.2
12.1	The student will make a 5-10 minute formal oral presentation.	7.2
MATH		
A.1	The student will solve linear equations and inequalities in one variable, solve literal equations (formulas) for a given variable, and apply these skills to solve practical problems.	7.1, 7.2
A.7	The student will determine the slope of a line when given an equation of the line, the graph of the line, or two points on the line.	7.2
AII.7	The student will solve equations containing rational expressions and equations containing radical expressions algebraically and graphically.	7.1, 7.2
G.5	The student will prove two triangles congruent or similar given information in the form of a figure or statement.	7.2
G.9	The student will use measures of interior and exterior angles of polygons to solve problems.	7.2
SCIENCE		
PH.13	The student will investigate and understand how to diagram and construct basic electrical circuits and explain the function of various circuit components.	7.2

DUTY AREA
7. ANALYZING AC CIRCUITS

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
7.1 Determine current, voltage, and impedance in *RL*, *RC*, and *RLC* circuits.

PERFORMANCE OBJECTIVE
P7.1 Given *RL*, *RC*, and *RLC* circuits, schematic diagrams of each, and necessary equipment, determine the current, voltage, and impedance in the circuits with 100% accuracy.

PERFORMANCE MEASURE
M7.1 Instructor-prepared test, all calculations performed with 100% accuracy

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify components of *RC* and *RL* circuits.
2. Explain the formula $Z^2 = R^2 + (X_L - X_C)^2$.
3. State the effect of frequency changes on current, voltage, and impedance of each component of an *RLC* circuit.
4. Explain the relationship of reactance and impedance.
5. Describe why total impedance is capacitive or reactive.
6. Identify uses of *RL*, *RC*, and *RLC* circuits.
7. Calculate total capacitance.
8. Calculate capacitive reactance.
9. Calculate impedance.
10. Calculate inductive reactance.

DUTY AREA
7. ANALYZING AC CIRCUITS

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
7.2 Explain transformer operation.

PERFORMANCE OBJECTIVE
P7.2 Given a transformer and a multimeter, explain transformer operation. Explanation must include identifying primary and secondary leads, determining the turns ratio, voltage ratio, and efficiency of the transformer, and drawing a schematic diagram. All calculations must be performed with 100% accuracy.

PERFORMANCE MEASURE
M7.2 Instructor-prepared test, all calculations performed with 100% accuracy

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain induction.
2. Describe different types of transformer construction.
3. Draw schematic diagrams of different types of transformers.
4. State methods of identifying primary and secondary leads.
5. List all safety procedures to observe when connecting equipment to power lines.
6. Measure primary and secondary voltage.
7. Calculate turns ratio, voltage ratio, primary and secondary currents, and efficiency of a transformer.
8. Define characteristics of a multiple tap transformer.

DUTY AREA
7. ANALYZING AC CIRCUITS

COURSE
Electronic I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
7.3 Measure resistance, current, and voltage drop in an AC resistive circuit.

PERFORMANCE OBJECTIVE
P7.3 Given an AC resistive circuit, power source, circuit values, and test equipment, measure the resistance, current, and voltage drops in the circuit. All values must be measured to within 10% of the instructor's measurements.

PERFORMANCE MEASURE
M7.3 Instructor-prepared test, all values measured to within 10% of instructor's measurements

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Make measurements, using a VOM and an oscilloscope.
2. Measure voltage, current, and resistance in series and parallel circuits.
3. Identify and locate components.
4. Explain the difference between VOM and oscilloscope voltage readings (effective vs. peak).

DUTY AREA
7. ANALYZING AC CIRCUITS

COURSE
Electronics II (8537)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
7.4 Analyze filter circuits.

PERFORMANCE OBJECTIVE
P7.4 Given a filter circuit, test equipment, and instruction, analyze the filter circuit by determining the frequency response and drawing a frequency response curve.

PERFORMANCE MEASURE
M7.4 Student-produced analysis, frequency response accurately determined and curve drawn in accordance with standard graphic techniques

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss types of filter circuits.
2. Explain factors relating to phase and impedance of filters.
3. Demonstrate filter measurement techniques.
4. Set up one filter system and draw a frequency response curve through the active region of one filter. All axes should be fully labeled and the 3dB points indicated.

DUTY AREA
7. ANALYZING AC CIRCUITS

COURSE
Electronic Communications I (ETR 241)

TASK / COMPETENCY
7.5 Determine resonant frequencies in *LC* circuits.

PERFORMANCE OBJECTIVE
P7.5 Given information and *RLC* series and parallel circuits, determine the resonant frequencies in the circuits. All calculations must be within 5% of the instructor's calculations.

PERFORMANCE MEASURE
M7.5 Instructor-prepared test, all calculations within 5% of the instructor's calculations

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Define *RLC* circuit and O's of *RLC* circuits.
2. Explain various ways resonance is defined.
3. Apply reactance formulas to show why X_L must equal X_C at resonance.
4. Interpret $f_r = \frac{1}{2\pi\sqrt{LC}}$
5. Demonstrate use of the formula to find resonant frequency.
6. Explain the function of low-pass, high-pass, and band reject filter circuits.

DUTY AREA
7. ANALYZING AC CIRCUITS

COURSE
Electronic Applications II (ETR 124)

TASK / COMPETENCY
7.6 Use maximum power transfer theorem (AC).

PERFORMANCE OBJECTIVE
P7.6 Given a number of AC circuits, use the appropriate power transfer theorem to calcuate the maximum power that can be delivered to a variable load. All calculations must match the instructor's calculations.

PERFORMANCE MEASURE
M7.6 Instructor-prepared test, all calculations matching instructor's calculations

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain reasons for determining the maximum power that can be transferred.
2. Apply Kirchhoff's current law (KCL) (P6.9).
3. Develop Thevenin-equivalent networks and values (P6.14).
4. Explain factors in AC circuits affecting maximum power transfer that are not present in DC circuits.

DUTY AREA
7. ANALYZING AC CIRCUITS

COURSE
Industrial Electronics I (ETR 237)

TASK / COMPETENCY
7.7 Demonstrate power factor corrections.

PERFORMANCE OBJECTIVE
P7.7 Given instruction and a number of applications where power factor is a consideration, demonstrate power factor corrections. Corrective actions must be in accordance with instructor's guidelines, and all calculations must be within 10% of the instructor's calculations.

PERFORMANCE MEASURE
M7.7 Instructor-prepared test, all calculations within 10% of instructor's calculations and corrective actions noted acceptable

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Define *power factor, true power,* and *effective power.*
2. List factors affecting power factor.
3. Explain the detrimental effects of a power factor less than unity (100%).
4. Explain how to correct power factor.

DUTY AREA
7. ANALYZING AC CIRCUITS

COURSE
Electronic Applications II (ETR 124)

TASK / COMPETENCY
7.8 Analyze *RC, RL,* and *RLC* circuits, using transient analysis.

PERFORMANCE OBJECTIVE
P7.8 Given several *RC, RL,* and *RLC* circuits, a voltmeter, voltage source, oscilloscope, and a timing device, analyze the circuits, using transient analysis.

PERFORMANCE MEASURE
M7.8 Instructor-prepared test, transient responses in agreement with those determined by standard transient equations

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Review *RL* and *RC* networks.
2. Discuss application of standard transient equations.
3. Demonstrate measurements in *RC* and *RL* networks.
4. Construct *RC* and *RL* circuits, calculate π and voltage at 2 π, and verify calculations by measurement of voltages.

DUTY AREA
7. ANALYZING AC CIRCUITS

COURSE
Electronic Applications II (ETR 124)

TASK / COMPETENCY
7.9 Use Thevenin's and Norton's theorems to analyze AC networks.

PERFORMANCE OBJECTIVE
P7.9 Given a series-parallel AC circuit with complex impedances and a constant sine-wave energy source, use Thevenin's and Norton's theorems to analyze AC networks, computing V_{Th}, Z_{Th}, I_N, and Z_N. Calculations must be within 1% of the instructor's calculations.

PERFORMANCE MEASURE
M7.9 Instructor-prepared test, all calculations within 1% of instructor's calcuations

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. State Thevenin's theorem for AC circuits.
2. State the advantage of using Thevenin's theorem in AC circuits.
3. "Theveninize" several AC circuits containing complex impedances.
4. State Norton's theorem for AC circuits.
5. Explain the difference between a Thevenin equivalent circuit and a Norton equivalent circuit.
6. "Nortonize" several AC circuits containing complex impedances.
7. State two differences between a voltage source and a current source.
8. Convert a Thevenin equivalent circuit into a Norton equivalent circuit.
9. Demonstrate source conversions.

DUTY AREA
7. ANALYZING AC CIRCUITS

COURSE
Electronic Applications II (ETR 124)

TASK / COMPETENCY
7.10 Design and construct a voltage regulator circuit.

PERFORMANCE OBJECTIVE
P7.10 Given a specific requirement and necessary equipment, design and construct a voltage regulator circuit to meet all aspects of the requirement. The effects that line and load changes have on output voltage must be measured, and the percentage of regulation accomplished by the circuit calculated.

PERFORMANCE MEASURE
M7.10 Student-constructed voltage regulator circuit, all components meeting industry standards and all aspects of the specified requirement

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Give several applications for regulator circuits.
2. List the four types of regulator circuits.
3. Design and draw a schematic diagram of a zener diode voltage regulator circuit.
4. Construct the zener diode voltage regulator circuit.
5. State the purpose of current limiting in a voltage regulator circuit.
6. Measure the effects that line and load changes have on output voltage.
7. Calculate the percentage of regulation accomplished by the circuit.
8. Discuss transistor pass regulator circuits and switching regulator circuits.
9. Describe the application and operation of commercially-available regulator circuits.

DUTY AREA
7. ANALYZING AC CIRCUITS

COURSE
Electronic Communications I (ETR 241)

TASK / COMPETENCY
7.11 Analyze resonance.

PERFORMANCE OBJECTIVE
P7.11 Given a tuned circuit and appropriate test equipment to measure resonance *L* and *C*, analyze resonance by calculating the resonance and *Q* of a tuned circuit, then measuring the resonance and *Q* of the circuit. Calculations must be within 20% of the instructor's calculations.

PERFORMANCE MEASURE
M7.11 Instructor-prepared test, all calculations within 20% of the instructor's calculations

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Use the formulas $f_o = \frac{1}{2\pi\sqrt{LC}}$ and $Q = \frac{X_L}{R}$
2. Measure *Q*, bandwidth, 3dB points, and resonant frequencies of a tuned circuit.
3. Discuss series and parallel resonance.
4. Set up an appropriately coupled parallel tuned circuit, then calculate and measure f_o, *Q*, and bandwidth.
5. Plot the frequency response curve of the tuned circuit through the 40dB points.

DUTY AREA 8. IDENTIFYING AND ANALYZING SOLID STATE CHARACTERISTICS

8.1 Analyze the operation of a PN junction diode.
8.2 Demonstrate the uses of diodes.
8.3 Graph the characteristic curve of a zener diode.
8.4 Construct a half-wave rectifier circuit.
8.5 Construct a full-wave rectifier circuit.
8.6 Construct a voltage multiplier circuit.
8.7 Determine transistor characteristics and parameters.
8.8 Demonstrate the uses of transistors.
8.9 Analyze the uses of common solid state devices.
8.10 Troubleshoot transistor circuits.
8.11 Analyze the frequency responses of an AC amplifier.
8.12 Analyze tuned class C amplifiers.
8.13 Troubleshoot an amplifier.
8.14 Analyze complementary symmetrical amplifiers.
8.15 Analyze and troubleshoot oscillator circuits.
8.16 Classify families of integrated circuits.

RELATED ACADEMIC STANDARDS OF LEARNING

(Based on 1995 SOLs)

MATH		TECHNICAL COMPETENCY
A.1	The student will solve linear equations and inequalities in one variable, solve literal equations (formulas) for a given variable, and apply these skills to solve practical problems.	8.3, 8.10, 8.14
A.2	The student will represent verbal quantitative situations algebraically and evaluate these expressions for given replacement values of the variables.	8.3
All.7	The student will solve equations containing rational expressions and equations containing radical expressions algebraically and graphically.	8.3, 8.10, 8.14
G.2	The student will use pictorial representations, including computer software and coordinate methods to solve problems involving symmetry and transformation. This will include investigating and determining whether a figure is symmetric with respect to a line or a point and determining whether a figure has been translated, reflected, or rotated.	8.12

DUTY AREA
8. IDENTIFYING AND ANALYZING SOLID STATE CHARACTERISTICS

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
8.1 Analyze the operation of a PN junction diode.

PERFORMANCE OBJECTIVE
P8.1 Given the characteristic curve of a specified PN junction diode, analyze the operation of the diode, using the characteristic curve. Biasing effects must be included in the explanation.

PERFORMANCE MEASURE
M8.1 Instructor-prepared test, diode analyzed according to instructor-provided guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. List the semiconducting materials used as the base material for junction diodes.
2. Describe the crystal pattern formed by silicon atoms.
3. State how electrons move from the valence band to the conduction band.
4. Define the following terms: *recombinations, minority carrier, majority carrier, saturation current, bulk resistance,* and *breakdown voltage.*
5. Explain the process of doping semiconductor material to produce N-type and P-type semiconductors.
6. Discuss how the depletion region of a PN junction diode is developed.
7. List the barrier potential in volts for silicon and germanium.
8. Draw a block diagram of a junction diode in forward bias.
9. State what occurs in a junction diode when reverse bias is applied.
10. Find *Q*, the operating point of a specified junction diode by calculating and plotting a load line from given data.
11. Explain the effects of temperature on current flow (I_S) in a junction diode.
12. Graph a junction diode second approximation.
13. Perform an experiment to determine junction diode characteristics.
14. Graph the volt-amp curve of a PN junction diode.

DUTY AREA
8. IDENTIFYING AND ANALYZING SOLID STATE CHARACTERISTICS

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
8.2 Demonstrate the uses of diodes.

PERFORMANCE OBJECTIVE
P8.2 Given various diodes, necessary equipment, and instructor guidelines, demonstrate the uses of diodes by constructing various circuits that match the instructor's waveforms and output voltage measurements.

PERFORMANCE MEASURE
M8.2 Student-constructed circuits, all components rated acceptable according to criteria specified in instructor's guidelines, and results in agreement with instructor's waveforms and output voltage measurements

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Use schematics and wiring diagrams.
2. Explain the construction and operation of several different types of circuits.
3. Discuss practical applications of diodes.

DUTY AREA
8. IDENTIFYING AND ANALYZING SOLID STATE CHARACTERISTICS

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
8.3 Graph the characteristic curve of a zener diode.

PERFORMANCE OBJECTIVE
P8.3 Given a diode circuit with a $V_S = 20V$, $R_S = 1000$ ohms, and a breakdown voltage of 6V, graph the characteristic curve of a zener diode and calculate I_Z and V_Z. The graph must show the Q point, and all calculations must be within 1% of the instructor's calculations.

PERFORMANCE MEASURE
M8.3 Instructor-prepared test, graph rated acceptable according to instructor's guidelines and all calculations within 1% of instructor's calculations

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. List the three regions in which a zener diode can operate.
2. Calculate the power dissipation of a specified zener diode when V_Z and I_Z are given.
3. Explain why a zener diode is used as a voltage regulator.
4. Calculate a load line for a zener diode that has a breakdown voltage of 15V and $V_S = 20V$, $R_S = 1.5k$ ohms.
5. Calculate the second approximation of a zener diode that has a $V_Z = 10V$, and $R_S = 1k$ ohms, and $R_Z = 10$ ohms, and the applied voltage (V_S) changes from 20-40V.
6. List the two conditions a zener diode must meet to be a stiff zener regulator.
7. Explain the effect of temperature changes on zener voltage.
8. Calculate V_{Th} for a zener regulator with a load.
9. Explain why the maximum allowable series resistance in a zener regulator is referred to as the critical

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DUTY AREA
8. IDENTIFYING AND ANALYZING SOLID STATE CHARACTERISTICS

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
8.4 Construct a half-wave rectifier circuit.

PERFORMANCE OBJECTIVE
P8.4 Given tools, materials, and a schematic of a half-wave rectifier circuit, construct a half-wave rectifier circuit. The circuit's output waveform must be the positive alternation of the input signal.

PERFORMANCE MEASURE
M8.4 Student-constructed rectifier, all components rated acceptable according to criteria specified in instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Apply schematics and drawings.
2. Define the following terms: *root-mean square (RMS)*; *average (AVG)*; and *peak (P) voltage*.
3. Calculate the effective values and ripple factors of a half-wave rectifier.
4. Perform an experiment to determine the characteristics of a half-wave rectifier circuit.
5. Measure input and output voltages of a half-wave rectifier.
6. Use an oscilloscope to display the output of a half-wave rectifier.
7. Explain the peak inverse voltage (PIV) rating of a diode.
8. Troubleshoot a half-wave rectifier.

DUTY AREA
8. IDENTIFYING AND ANALYZING SOLID STATE CHARACTERISTICS

COURSE
Electronics (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
8.5 Construct a full-wave rectifier circuit.

PERFORMANCE OBJECTIVE
P8.5 Given tools, materials, a transformer, and schematics, construct a full-wave rectifier circuit. Rectifier must be operational and agree with the schematics in all respects.

PERFORMANCE MEASURE
M8.5 Student-constructed rectifier, all components rated acceptable according to criteria specififed in instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Draw schematics of a full-wave and a bridge rectifier.
2. Apply schematics and drawings.
3. Explain how secondary voltage is divided between diodes in a full-wave rectifier.
4. Explain how input frequency is doubled by a full-wave rectifier.
5. Explain the advantage of a bridge rectifier's output over that of other full-wave rectifiers.
6. Make a chart listing the characteristics of half-wave, full-wave, and bridge rectifiers.
7. Perform experiments on full-wave and bridge rectifiers.
8. Explain how filtering affects rectifier output voltage.
9. Troubleshoot a full-wave rectifier.

DUTY AREA
8. IDENTIFYING AND ANALYZING SOLID STATE CHARACTERISTICS

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
8.6 Construct a voltage multiplier circuit.

PERFORMANCE OBJECTIVE
P8.6 Given the necessary materials, tools, and components, construct a voltage multiplier circuit that delivers an output voltage three times greater than the input voltage.

PERFORMANCE MEASURE
M8.6 Student-constructed multiplier, all components rated acceptable according to criteria specified in instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Draw schematics for a voltage doubler, tripler, and quadrupler.
2. State the purpose of voltage multiplier circuits.
3. Determine experimentally the effect on the output voltage when a voltage multiplier is increased from doubler to tripler.
4. State two purposes for limiters.
5. Determine experimentally the effect biasing has on a limiter.
6. Explain how a clamper circuit modifies an input signal swing.
7. Determine experimentally how the difference between the *RL* and *RC* time constant and time period causes a modification of the input signal.
8. Explain why a capacitively-coupled source will not produce an output signal across an unbalanced load.
9. Troubleshoot multiplier circuits.

DUTY AREA
8. IDENTIFYING AND ANALYZING SOLID STATE CHARACTERISTICS

COURSE
Electronics I (8536)
Electronics II (ETR 124)

TASK / COMPETENCY
8.7 Determine transistor characteristics and parameters.

PERFORMANCE OBJECTIVE
P8.7 Given various transistors, a reference manual, and an instructor-provided lab worksheet, determine transistor characteristics and parameters. For each transistor, the characteristic curve and schematic symbols must be drawn and labeled.

PERFORMANCE MEASURE
M8.7 Instructor-prepared worksheet, all drawings and labels in agreement with instructor's data sheet

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain the biasing required by a transistor to operate.
2. Explain the relationship of I_E to I_B and I_C.
3. Describe the voltage potential required by the emitter-base junction.
4. State the meaning of *alpha*, *beta*, h_{fe}, V_C, V_E, V_B, V_{CE}, and *transit time*.
5. Identify transistors by case and number.
6. Identify leads of various transistors based on case design, service literature, and/or test equipment.
7. Perform experiments to obtain data for plotting characteristic curves.

DUTY AREA
8. IDENTIFYING AND ANALYZING SOLID STATE CHARACTERISTICS

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
8.8 Demonstrate the uses of transistors.

PERFORMANCE OBJECTIVE
P8.8 Given a laboratory assignment sheet, breadboard, and other necessary equipment and supplies, demonstrate the uses of transistors by constructing a circuit. Completed breadboard circuit must match schematic diagram on lab sheet, and voltage measurements must agree with measurements on instructor's data sheet.

PERFORMANCE MEASURE
M8.8 Student-constructed circuit, all components in accordance with lab sheet specifications and voltage measurements in agreement with instructor's measurements

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Describe the basic circuit configurations of a transistor amplifier.
2. Explain the advantages and disadvantages of the CE, CC, and CB circuits.
3. Construct a circuit to demonstrate the use of a transistor as a switch, and explain its operation.
4. Discuss practical applications of transistors.

DUTY AREA
8. IDENTIFYING AND ANALYZING SOLID STATE CHARACTERISTICS

COURSE
Electronics II (8537)
Electronic Applications II (ETR 124)
Industrial Electronics I (ETR 237)

TASK / COMPETENCY
8.9 Analyze the uses of common solid state devices

PERFORMANCE OBJECTIVE
P8.9 Given information pertaining to certain solid state devices, and schematic diagrams, analyze the uses of common solid state devices. Analysis should be made in accordance with directions in instructor-provided lab sheet.

PERFORMANCE MEASURE
M8.9 Student-produced analysis, all items meeting specifications in instructor-provided lab sheet

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Review the construction and operation of transistors, diodes, and other solid state devices.
2. Describe the function of an FET, MOSFET, and PUT.
3. List uses of a diode, transistor, LED, DIAC, TRIAC, SCR, and LASCR.
4. Describe the function of a SUS, SBS, photodiode, and a phototransistor.
5. Construct a simple zener diode circuit and explain its operation.
6. State the effects of electrostatic discharge.

DUTY AREA
8. IDENTIFYING AND ANALYZING SOLID STATE CHARACTERISTICS

COURSE
Electronics II (8537)

TASK / COMPETENCY
8.10 Troubleshoot transistor circuits.

PERFORMANCE OBJECTIVE
P8.10 Given equipment, supplies, and instruction, troubleshoot transistor circuits. Troubleshooting steps must include construction of a transistor circuit in accordance with specifications on lab sheet, hypothetical calculations, operational test, verification of circuit operation by instructor, and identification of faulty components.

PERFORMANCE MEASURE
M8.10 Demonstration, all steps completed in accordance with instructor's guidelines and circuits operational

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Construct a single state transistor circuit.
2. Calculate the currents and voltages of a transistor circuit.
3. Analyze circuit problems using voltage and resistance checks.
4. Demonstrate the use of an ohmmeter (VOM/DMM) to check both diodes and transistors.
5. Demonstrate the use of a diode and transistor checker.

DUTY AREA
8. IDENTIFYING AND ANALYZING SOLID STATE CHARACTERISTICS

COURSE
Electronic Communications I (ETR 241)

TASK / COMPETENCY
8.11 Analyze the frequency response of an AC amplifier.

PERFORMANCE OBJECTIVE
P8.11 Given a circuit diagram of a common-emitter RC coupled amplifier and the necessary circuit parameters, analyze the frequency response of the amplifier by measuring the cut-off frequencies. All measurements must be within 20% of the instructor's measurements.

PERFORMANCE MEASURE
M8.11 Instructor-prepared test, all measurements within 20% of instructor's measurements

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain the relationship between the cut-off frequency and the half-power point.
2. Measure the cut-off frequencies of the input and output networks of a common-emitter RC coupled amplifier, given necessary circuit parameters.
3. Explain how an emitter bypass capacitor affects the frequency response of an RC coupled common-emitter amplifier.
4. State Miller's theorem, the effects of Miller's theorem, and its most important application.
5. Define current-gain-bandwidth product.
6. Perform an experiment to measure the frequency response of an audio amplifier.
7. Measure the cut-off frequencies of a CE amplifier, given necessary circuit parameters and a data sheet for the transistor.

DUTY AREA
8. IDENTIFYING AND ANALYZING SOLID STATE CHARACTERISTICS

COURSE
Electronic Communications I (ETR 241)

TASK / COMPETENCY
8.12 Analyze tuned class C amplifiers.

PERFORMANCE OBJECTIVE
P8.12 Given the schematic diagram for a tuned class C amplifier and the necessary values and waveforms at each point in the circuit, analyze the amplifier by explaining each waveform shown.

PERFORMANCE MEASURE
M8.12 Instructor-prepared test, all items completed and analyzed in conformance with the theory of operation

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Define class C operation of an amplifier, and explain why class C amplifiers drive a resonant tank circuit.
2. Draw the frequency response curve for a parallel resonant tank circuit, and state the formulas used to calculate f_r, bandwidth, and Q of the circuit.
3. Define *duty cycle* and *harmonics*.
4. Explain how the load power, transistor dissipation, current drain, and stage efficiency of a class C amplifier differ from those of class A and B amplifiers.
5. Explain how a tuned class C circuit can be used as a frequency multiplier.

DUTY AREA
8. IDENTIFYING AND ANALYZING SOLID STATE CHARACTERISTICS

COURSE
Electronics I (8536)
Electronic Applications II (ETR 124)

TASK / COMPETENCY
8.13 Troubleshoot an amplifier.

PERFORMANCE OBJECTIVE
P8.13 Given a defective solid state audio amplifier, appropriate schematics, power supply, and test equipment, troubleshoot the amplifier. Troubleshooting steps must include performance of operational checks, identification of faulty section, identification of faulty component, replacement of faulty component, and operational test.

PERFORMANCE MEASURE
M8.13 Demonstration, all steps in accordance with instructor's guidelines and amplifier operational

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Review the theory of multi-stage amplifiers.
2. Review use of VOM/DMM to check diodes and transistors.
3. Demonstrate troubleshooting techniques.
4. Interpret schematcs.
5. Demonstrate performance measurements.
6. Troubleshoot three or more amplifiers to the component level, repair, and operationally test each.

DUTY AREA
8. IDENTIFYING AND ANALYZING SOLID STATE CHARACTERISTICS

COURSE
Electronics I (8536)

TASK / COMPETENCY
8.14 Analyze complementary symmetrical amplifiers.

PERFORMANCE OBJECTIVE
P8.14 Given a solid state complementary symmetrical amplifier, appropriate power supplies, test equipment, and manufacturer's specifications, analyze amplifier, performing operational tests, cross-over distortion tests, and tests to confirm the operation of the amplifier to the manufacturer's specifications.

PERFORMANCE MEASURE
M8.14 Demonstration, all tests completed according to manufacturer's specifications and rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss the theory of Darlington pairs.
2. Explain complementary amplifiers.
3. Present the theory of complemenetary symmetrical amplifiers.
4. Demonstrate protection circuits in complementary symmetrical amplifiers.
5. Demonstrate feedback and bias in complementary symmetrical amplifiers.
6. Draw a schematic of a complementary symmetrical amplifier and identify the following:
   a. line of symmetry
   b. complementary components
   c. Darlington amplifiers
   d. input network and biasing
   e. protective circuits
   f. components that can cause cross-over distortion.
7. Interpret manufacturer's specifications.
8. Describe various methods for confirming whether manufacturer's specifications are met.

DUTY AREA
8. IDENTIFYING AND ANALYZING SOLID STATE CHARACTERISTICS

COURSE
Electronics I (8536)
Electronic Communications I (ETR 241)

TASK / COMPETENCY
8.15 Analyze and troubleshoot oscillator circuits.

PERFORMANCE OBJECTIVE
P8.15 Given appropriate test equipment and components, analyze and troubleshoot an oscillator circuit by constructing an oscillator circuit in accordance with specifications on a lab sheet, performing hypothetical calculations necessary to insure oscillation and stability, performing an operational test, having circuit operation verified by instructor, and identifying any faulty component.

PERFORMANCE MEASURE
M8.15 Demonstration, all steps completed in accordance with instructor's guidelines and circuit operational

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain oscillator theory, including loop gain greater than one, feedback in phase, and frequency on time determining network.
2. Demonstrate verification on loop gain greater than one, feedback in phase, and frequency on time determining network.
3. Demonstrate measurements of oscillator stability, frequency, and amplitude of output.
4. Construct at least two types of oscillators, verify operation, draw schematics, and identify the frequency determining network, the loop, and phase of the signal through the loop to verify feedback phase.

DUTY AREA

8. IDENTIFYING AND ANALYZING SOLID STATE CHARACTERISTICS

COURSE

Electronics II (8437)

TASK / COMPETENCY

8.16 Classify families of integrated circuits.

PERFORMANCE OBJECTIVE

P8.16 Given a data sheet, reference manuals, and 10 integrated circuits (various packaging), classify families of integrated circuits by locating in the manual and notating on the data sheet the supply voltage, operating temperature range, grounds, power dissipation, and linear or nonlinear classification for each circuit. Classification must be correct for at least eight of the ten circuits.

PERFORMANCE MEASURE

M8.16 Instructor-prepared test, all steps and final classification correct for at least eight of ten circuits

ENABLING OBJECTIVES / LEARNING ACTIVITIES

1. Define *monolithic, thick-film, integrated circuit (IC),* and *linear.*
2. Explain the differences between linear integrated circuits and nonlinear integrated circuits.
3. Describe applications of linear and nonlinear integrated circuits.
4. Identify common linear *IC* packages, pin assignments, and schematic representations.
5. List handling precautions.
6. Locate specifications of circuits in reference manuals.

DUTY AREA 9. DEMONSTRATING FABRICATION TECHNIQUES

9.1 Demonstrate wire soldering techniques.
9.2 Demonstrate components soldering techniques.
9.3 Construct a wire harness (interface).
9.4 Prepare shielded wire and coaxial cables for installation.
9.5 Demonstrate proper handling techniques for static-sensitive components.
9.6 Develop electronic system layout (packaging).
9.7 Perform CAD layout techniques.

DUTY AREA
9. DEMONSTRATING FABRICATION TECHNIQUES

COURSE
Electronics I (8536)

TASK / COMPETENCY
9.1 Demonstrate wire soldering techniques.

PERFORMANCE OBJECTIVE
P9.1 Given wire and soldering equipment, demonstrate wire soldering techniques by splicing the wires with a soldered connection. Demonstration must include stripping insulation, cutting wires to correct lengths, twisting wires, and using cold solder and frosty.

PERFORMANCE MEASURE
M9.1 Instructor-prepared checklist, all items rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain procedures used in splicing wire conductors together.
2. Demonstrate wire insulation stripping.
3. Demonstrate cutting wires to the correct length and twisting wires.
4. Discuss cold solder and frosty as applied to soldering.
5. Show methods of soldering and applying wirenuts and tape.
6. Discuss places where splices are used.
7. Connect a number of pieces of wire by soldering.

DUTY AREA
9. DEMONSTRATING FABRICATION TECHNIQUES

COURSE
Electronics I (8536)

TASK / COMPETENCY
9.2 Demonstrate components soldering techniques.

PERFORMANCE OBJECTIVE
P9.2 Given selected components, printed circuit (PC) boards, and soldering equipment, demonstrate components soldering techniques by soldering and unsoldering components. Demonstration must include using ground straps and heat sinks, cleaning soldered areas, and repairing a PC board.

PERFORMANCE MEASURE
M9.2 Instructor-prepared checklist, all items rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain procedures for removing and replacing components.
2. Demonstrate use of ground straps and heat sinks.
3. Demonstrate soldering techniques used to solder discrete devices (single-sided and double-sided with plated-through holes), integrated circuits (IC), and dual-in-line package (DIP) components to a PC board.
4. Demonstrate cleaning soldered area.
5. Make repairs to a PC board.
6. Demonstrate techniques used to desolder components from PC boards, using wick and desoldering tools, and components and wires from a chassis.

DUTY AREA
9. DEMONSTRATING FABRICATION TECHNIQUES

COURSE
Electronics II (8537)

TASK / COMPETENCY
9.3 Construct a wire harness (interface).

PERFORMANCE OBJECTIVE
P9.3 Given a wire layout drawing, tools, and materials, construct a wire harness (interface). All wires in the harness must have identifying alphanumeric or color codes to indicate the wires' functions.

PERFORMANCE MEASURE
M9.3 Student-constructed wire harness, all components meeting criteria specified in instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain the difference between a harness and a cable.
2. Draw a harness layout.
3. Demonstrate methods to splice wires.
4. Explain how to measure wire size using a wire gauge.
5. Prepare wires for soldering (P9.1).
6. List four types of wire connections.
7. Terminate a wire run with a (solderless) crimp connection.
8. Insulate both splice and solderless connectors with heat shrink tubing.
9. Construct a wire harness jig.
10. Connect a multi-pin connector to a wire harness.

DUTY AREA
9. DEMONSTRATING FABRICATION TECHNIQUES

COURSE
Electronics II (8537)

TASK / COMPETENCY
9.4 Prepare shielded wire and coaxial cables for installation.

PERFORMANCE OBJECTIVE
P9.4 Given shielded wire, coaxial cables, tools, and terminals, prepare the shielded wire and coaxial cables for installation by mounting terminals on each end of the wire and cables. The finished product must meet industry soldering standards.

PERFORMANCE MEASURE
M9.4 Demonstration, all steps rated acceptable and finished product meeting industry soldering standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain the difference between shielded wire and coaxial cable.
2. Demonstrate preparation of shielded wire and coaxial cable for terminal installation.
3. Explain what *skin effect* is and what type of material is used to minimize it.
4. Solder a phono plug to a shielded wire and to coaxial cable.
5. Connect a Bayonet Naval Connector (BNC) or other high frequency connector to a coaxial cable.

DUTY AREA
9. DEMONSTRATING FABRICATION TECHNIQUES

COURSE
Microprocessor Applications I (ETR 261)

TASK / COMPETENCY
9.5 Demonstrate proper handling techniques for static-sensitive components.

PERFORMANCE OBJECTIVE
P9.5 Given a number of static-sensitive components, demonstrate proper handling techniques to preclude damage to or degradation of the components. Demonstration should include use of wrist guards and antistatic table mats.

PERFORMANCE MEASURE
M9.5 Demonstration, all steps rated acceptable according to instructor's guidelines and components handled without damage or degradation due to static

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss permanent and intermittent damage due to static electricity.
2. Demonstrate use of wrist guards and antistatic table mats.
3. Mount a static-sensitive component, such as a MOSFET, to a PC board.

DUTY AREA
9. DEMONSTRATING FABRICATION TECHNIQUES

COURSE
Seminar and Project (ETR 298)

TASK / COMPETENCY
9.6 Develop electronic system layout (packaging).

PERFORMANCE OBJECTIVE
P9.6 Given system criteria and specifications for an electronic system or piece of electronic equipment, develop electronic system layout (packaging) to meet the criteria and specifications of the system. Packaging must be cost effective and meet all technical requirements.

PERFORMANCE MEASURE
M9.6 Student-developed packaging, rated acceptable based on criteria for cost effectiveness specified in system specifications and instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss the factors that must be considered in electronic layout.
2. Discuss considerations in component or subsystem selection related to cost effectiveness, availability, size, and environmental considerations.
3. Discuss environmental and human engineering factors to be considered in layout and construction.
4. List the factors influencing the selection of chassis materials and configurations.
5. Select locations for component placement.

DUTY AREA
9. DEMONSTRATING FABRICATION TECHNIQUES

COURSE
Computer Aided Drafting (DRF 231)

TASK / COMPETENCY
9.7 Perform CAD layout techniques.

PERFORMANCE OBJECTIVE
P9.7 Given the necessary computer equipment, perform CAD layout techniques by producing a CAD drawing. Demonstration must include use of the plotter/printer, use of computer menus, and application of symbols and dimensions, and drawing must meet accepted drafting standards.

PERFORMANCE MEASURE
M9.7 Student-produced drawing, all components meeting specified drafting standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss basic computer operations.
2. Discuss capabilities and limitations of CAD.
3. Operate computer and components to include plotter/printer.
4. Use computer menus.
5. Describe the commands used in drawing preparation.
6. Apply symbols and dimensions.
7. Demonstrate preparing drawings from sketches.

DUTY AREA 10. APPLYING DIGITAL LOGIC TECHNOLOGY

10.1 Identify digital circuitry, signals, and practices.
10.2 Identify logic symbols and Boolean expressions.
10.3 Construct truth tables for logic circuits.
10.4 Construct encoder and decoder circuits.
10.5 Describe sequential logic circuits.
10.6 Construct flip-flops, counters, and registers.
10.7 Explain digital memory circuits.
10.8 Troubleshoot combinational and sequential logic circuits.
10.9 Troubleshoot a complex logic circuit.
10.10 Design a seven-segment display circuit.
10.11 Troubleshoot digital-to-analog (D/A) and analog-to-digital (A/D) converter circuits.
10.12 Use Boolean expressions to solve complex digital circuitry.

RELATED ACADEMIC STANDARDS OF LEARNING

(Based on 1995 SOLs)

ENGLISH		TECHNICAL COMPETENCY
11.9	The student will analyze, evaluate, synthesize, and organize information from a variety of sources into a documented paper dealing with a question, problem, or issue.	10.1, 10.2, 10.5
12.1	The student will make a 5-10 minute formal oral presentation.	10.1, 10.5
12.4	The student will read a variety of print material.	10.7
12.8	The student will write documented research papers.	10.2
MATH		
A.1	The student will solve linear equations and inequalities in one variable, solve literal equations (formulas) for a given variable, and apply these skills to solve practical problems.	10.2, 10.3, 10.4, 10.8
A.2	The student will represent verbal quantitative situations algebraically and evalute these expressions for given replacement values of the variables.	10.2, 10.3, 10.4, 10.8
A.3	The student will justify steps used in simplifying expressions and solving equations and inequalities. Justification will include the use of concrete objects, pictorial representations, and the properties of real numbers.	10.2, 10.3, 10.4, 10.8
A.7	The student will determine the slope of a line when given an equation of the line, the graph of the line, or two points on the line.	10.2, 10.3, 10.4, 10.8
A.9	The student will solve systems of two linear equations in two variables, both algebraically and graphically, and apply these techniques to solve practical problems.	10.2, 10.3, 10.4, 10.8
A.10	The student will apply the laws of exponents to perform operations on expressions with integral exponents, using scientific notation when appropriate.	10.2, 10.3, 10.4, 10.8
A.11	The student will add, subtract, and multiple polynomials and divide polynomials with monomial divisors, using concrete objects, pictorial representations, and algebraic manipulations.	10.2, 10.3, 10.4, 10.8
A.12	The student will factor completely first- and second-degree binomials and trinomials in one or two variables.	10.2, 10.3, 10.4, 10.8
A.13	The student will estimate square roots to the nearest tenth and use a calculator to compute decimal approximations of radicals.	10.2, 10.3, 10.4, 10.8

A.14	The student will solve quadratic equations in one variable both algebraically and graphically.	10.2, 10.3, 10.4, 10.8
AII.2	The student will add, subtract, multiply, divide, and simplify rational expressions, including complex fractions.	10.2, 10.3, 10.4, 10.8
AII.7	The student will solve equations containing rational expressions and equations containing radical expressions algebraically and graphically.	10.2, 10.3, 10.4, 10.8

DUTY AREA
10. APPLYING DIGITAL LOGIC TECHNOLOGY

COURSE
Electronics II (8537)
Logic Circuits and Systems (ETR 206)

TASK / COMPETENCY
10.1 Identify digital circuitry, signals, and practices.

PERFORMANCE OBJECTIVE
P10.1 Given a list of equipment and a handout of waveform diagrams, identify digital circuitry, signals, and practices. Identification should include labeling signals as binary 0 and 1, and all items must be identified with at least 80% accuracy.

PERFORMANCE MEASURE
M10.1 Instructor-prepared test, all items completed with at least 80% accuracy

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Define *integrated circuit (IC), dual-in-line package (DIP), flat-pack, digital,* and *linear.*
2. Draw the block diagram of a 14-pin DIP integrated circuit, and label the pin numbers in order.
3. Explain the difference between a digital and an analog signal.
4. List five devices that use digital circuits.
5. Draw a digital signal that is three volts in amplitude.
6. Label the signal in 5 above as binary 0 and 1.
7. Construct a free-running clock circuit and measure its frequency.
8. Discuss the application of digital circuitry to the electronics industry.

DUTY AREA
10. APPLYING DIGITAL LOGIC TECHNOLOGY

COURSE
Electronics II (8537)
Logic Circuits and Systems (ETR 206)

TASK / COMPETENCY
10.2 Identify logic symbols and Boolean expressions.

PERFORMANCE OBJECTIVE
P10.2 Given a list of logic symbols and Boolean expressions, identify the symbols and expressions. Identification should include explanation of a truth table, differentiation between positive and negative logic, and calculations involving Boolean algebra. All items must be completed with at least 80% accuracy.

PERFORMANCE MEASURE
M10.2 Instructor-prepared test, all items completed with at least 80% accuracy

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Draw AND and OR gate symbols and the Boolean expression of each.
2. Draw an inverter symbol and the Boolean expression of it.
3. Draw NAND and NOR gate symbols and the Boolean expression of each.
4. Draw XOR and XNOR gate symbols and the Boolean expression of each.
5. Construct specified logic circuits.
6. Explain how a NAND gate can be used to construct other gates.
7. Explain how a truth table is constructed.
8. Differentiate between positive and negative logic.
9. Explain the difference between transistor-transistor logic (TTL) and complementary metal oxide semiconductor (CMOS) circuits.
10. Perform calculations involving basic Boolean algebra.

DUTY AREA
10. APPLYING DIGITAL LOGIC TECHNOLOGY

COURSE
Electronics II (8537)
Logic Circuits and Systems (ETR 206)

TASK / COMPETENCY
10.3 Construct truth tables for logic circuits.

PERFORMANCE OBJECTIVE
P10.3 Given instruction, logic circuit diagrams, and Boolean expressions, construct truth tables for logic circuits by using appropriate Boolean expressions.

PERFORMANCE MEASURE
M10.3 Student-produced truth tables, all components rated acceptable based on instructor-provided logic circuit diagrams

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Draw a circuit diagram from a Boolean expression.
2. Draw a circuit diagram from a truth table.
3. Construct a truth table from a Boolean expression.
4. Form a maxterm Boolean expression from a truth table.
5. Simplify a Boolean expression.
6. Draw a NAND logic diagram from a four-variable truth table.

DUTY AREA
10. APPLYING DIGITAL LOGIC TECHNOLOGY

COURSE
Electronics II (8537)
Logic Circuits and Systems (ETR 206)

TASK / COMPETENCY
10.4 Construct encoder and decoder circuits.

PERFORMANCE OBJECTIVE
P10.4 Given an information sheet, equipment, and supplies, construct encoder and decoder circuits. Constructed circuits must operate as specified in the information sheet and must be accompanied by a data sheet showing codes and resulting displays.

PERFORMANCE MEASURE
M10.4 Student-produced circuits, all components fully operational and in accordance with specifications in instructor-provided information sheets

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Convert decimal numbers to Binary Coded Decimal (BCD).
2. Convert decimal numbers to Excess -3 Code.
3. Explain the function of a 74147, and draw a pinout diagram.
4. Wire a seven-segment LED to display all segments.
5. Explain the function of a 7447, and draw a pinout diagram.
6. Troubleshoot an encoder and a decoder circuit.
7. Explain the function of a 74153 and a 74155, and draw a pinout diagram for each.
8. Troubleshoot multiplexer and demultiplexer circuits.

DUTY AREA
10. APPLYING DIGITAL LOGIC TECHNOLOGY

COURSE
Electronics II (8537)
Logic Circuits and Systems (ETR 206)

TASK / COMPETENCY
10.5 Describe sequential logic circuits.

PERFORMANCE OBJECTIVE
P10.5 Given a sequential logic circuit diagram and a set of pulse train signals, describe sequential logic circuits by indicating the output signal that would appear at each time increment of the input pulse train. Description should include solving pulse train problems for an IC counter.

PERFORMANCE MEASURE
M10.5 Instructor-prepared test, all output signals at each time increment in agreement with those recorded on instructor's data sheet

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Define *sequential, latch, flip-flop, synchronous, asynchronous, positive edge, triggering, disabled, enabled,* and *toggling.*
2. Explain the function of a flip-flop.
3. Explain how a latch is used to store information.
4. Construct a frequency divider circuit.
5. Solve pulse train problems for an IC counter.
6. Explain the differences in serial load and parallel load shift register.

DUTY AREA
10. APPLYING DIGITAL LOGIC TECHNOLOGY

COURSE
Electronics II (8537)
Logic Circuits and Systems (ETR 206)

TASK / COMPETENCY
10.6 Construct flip-flops, counters, and registers.

PERFORMANCE OBJECTIVE
P10.6 Given instruction, parts, equipment, and schematic diagrams, construct flip-flop, counter, and register circuits. The circuits must be operational and constructed in accordance with schematic specifications, and all calculations must be within ± 5% of the ideal value.

PERFORMANCE MEASURE
M10.6 Student-produced circuits, all components in accordance with instructor-provided schematics and fully operational, and all calculations within ± 5% of ideal value

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Describe the operation of a D-type flip-flop.
2. Construct a debounce switch circuit that uses NOR gates.
3. Construct a 4-bit shift register.
4. Construct a divider-by-two circuit using flip-flops.
5. Describe the operation of a binary counter.
6. Interpret a flip-flop truth table and construct a circuit based on the table.
7. Draw pulse train diagrams of two flip-flop circuits.

DUTY AREA
10. APPLYING DIGITAL LOGIC TECHNOLOGY

COURSE
Electronics II (8537)
Logic Circuits and Systems (ETR 206)

TASK / COMPETENCY
10.7 Explain digital memory circuits.

PERFORMANCE OBJECTIVE
P10.7 Given manufacturer's literature on a memory IC, explain digital memory circuits by explaining how data is loaded into the circuit and how it is retrieved. Explanations should include read, write, and enable signals and must be in accordance with manufacturer's literature.

PERFORMANCE MEASURE
M10.7 Instructor-prepared test, explanations rated acceptable according to manufacturer's literature

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Describe the types of memory ICs, including static, dynamic, and EPROM (Erasable Programmable Read-Only Memory).
2. Discuss the architecture of memory ICs.
3. Explain memory system architecture.
4. Describe the signals and timing involved in memory systems, including read, write, and enable signals (address decode, etc.).
5. Explain the operation of several different manufacturers' memory integrated circuits by drawing timing diagrams, showing data flow to a particular IC, drawing the architecture of the memory system, and showing how any dynamic memory is refreshed (if applicable).

DUTY AREA
10. APPLYING DIGITAL LOGIC TECHNOLOGY

COURSE
Electronics II (8537)
Logic Circuits and Systems (ETR 206)

TASK / COMPETENCY
10.8 Troubleshoot combinational and sequential logic circuits.

PERFORMANCE OBJECTIVE
P10.8 Given instructor's guidelines, test equipment, and materials, troubleshoot combinational and sequential logic circuits by using truth tables, using test equipment, following procedures specified in instructor's guidelines, and restoring circuit operations.

PERFORMANCE MEASURE
M10.8 Demonstration, all steps completed in accordance with instructor's guidelines and circuits fully operational

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate use of a logic probe.
2. Demonstrate use of a logic monitor.
3. Draw the output waveforms of sequential logic circuits.
4. Explain the steps in troubleshooting.
5. Explain the use of truth tables in troubleshooting.
6. Use manufacturer's literature.
7. Develop a troubleshooting plan.
8. Construct a logic probe or logic pulser.

DUTY AREA
10. APPLYING DIGITAL LOGIC TECHNOLOGY

COURSE
Logic Circuits and Systems (ETR 206)

TASK / COMPETENCY
10.9 Troubleshoot a complex logic circuit.

PERFORMANCE OBJECTIVE
P10.9 Given a complex logic circuit with a malfunction, test equipment, and supplies troubleshoot the circuit. Troubleshooting steps must include development of a troubleshooting plan, determination of cause of malfunction, replacement/repair of component or circuit, operational check, and verification of circuit operation by instructor.

PERFORMANCE MEASURE
M10.9 Demonstration, all steps completed in accordance with instructor's guidelines and circuit operational

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss common logic circuit and remedies.
2. Use manufacturer's literature.
3. Perform functional checks.
4. Prepare a troubleshooting plan.
5. Perform troubleshooting procedures.
6. Repair or remove and replace faulty components.

DUTY AREA
10. APPLYING DIGITAL LOGIC TECHNOLOGY

COURSE
Logic Circuits and Systems (ETR 206)

TASK / COMPETENCY
10.10 Design a seven-segment display circuit.

PERFORMANCE OBJECTIVE
P10.10 Given circuit requirements, design a seven-segment display circuit controlled by on-off switches. Design must include a schematic and block diagrams and calculation of LED current.

PERFORMANCE MEASURE
M10.10 Student-produced design, meeting all criteria specified in instructor-provided guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Develop a schematic and block diagrams.
2. Calculate LED current when V_S = 12V, V_{LED} = 1.5V, and R_S = 1000 ohms.
3. State the frequency at which reverse recovery time becomes important.
4. Explain design parameters that affect LED brightness.

DUTY AREA
10. APPLYING DIGITAL LOGIC TECHNOLOGY

COURSE
Microprocessor Application II (ETR 262)

TASK / COMPETENCY
10.11 Troubleshoot digital-to-analog (D/A) and analog-to-digital (A/D) converter circuits.

PERFORMANCE OBJECTIVE
P10.11 Given defective D/A and A/D converters, equipment, and materials, troubleshoot the converter circuits. Troubleshooting results must restore circuit operation, show the use of test equipment, and meet prescribed troubleshooting procedures.

PERFORMANCE MEASURE
M10.11 Demonstration, all steps completed in accordance with instructor's guidelines and circuits operational

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Define *digital-to-analog* and *analog-to-digital* conversions, *resolution, accuracy,* and *successive approximation.*
2. Construct a digital-to-analog converter, using a summing op amp.
3. Use manufacturer's literature.
4. Develop a troubleshooting plan.
5. Verify operation of various components.
6. Troubleshoot circuit malfunctions.
7. Verify circuit operation.

DUTY AREA
10. APPLYING DIGITAL LOGIC TECHNOLOGY

COURSE
Logic Circuits and Systems (ETR 206)

TASK / COMPETENCY
10.12 Use Boolean expressions to solve complex digital circuitry.

PERFORMANCE OBJECTIVE
P10.12 Given Boolean laws and a complex digital circuit, use Boolean expressions to solve complex digital circuitry by writing the Boolean expression for a complex digital circuit, reducing the Boolean expression to its simplest form, rewriting the Boolean expression to fit existing logic, and drawing the resultant logic.

PERFORMANCE MEASURE
M10.12 Instructor-prepared checklist, all items rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss basic Boolean expressions.
2. Solve simple Boolean expressions.
3. Write Boolean expressions to fit existing logic.
4. Write Boolean expressions for several given logic diagrams.
5. Draw logic diagrams from given Boolean expressions.
6. Discuss complex Boolean laws.
7. Simplify complex Boolean expressions and logic diagrams, using Boolean algebra.

DUTY AREA 11. APPLYING COMPUTER TECHNOLOGY

11.1 Identify microcomputer applications.
11.2 Interface peripheral equipment.
11.3 Identify characteristics of various information storage systems.
11.4 Write and debug a software problem.
11.5 Troubleshoot a digital computer and peripherals.
11.6 Identify computer architecture.
11.7 Develop data collection applications.
11.8 Apply programmable controls.
11.9 Apply standard computer operating procedures.
11.10 Troubleshoot serial and parallel communications networks.
11.11 Construct a computer.
11.12 Write a program in a higher order language.

RELATED ACADEMIC STANDARDS OF LEARNING

(Based on 1995 SOLs)

ENGLISH

12.4 The student will read a variety of print material.

TECHNICAL COMPETENCY

11.1

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DUTY AREA
11. APPLYING COMPUTER TECHNOLOGY

COURSE
Electronics II (8537)
Industrial Electronics (ETR 237)

TASK / COMPETENCY
11.1 Identify microcomputer applications.

PERFORMANCE OBJECTIVE
P11.1 Given information, resources, and instructor's guidelines, identify microcomputer applications. Report must include the two main categories of microcomputer applications, four examples of "dedicated" control, the five categories of general purpose microcomputers, the concepts of computer-aided instruction, computer-assisted drafting, and computer-integrated manufacturing, and ways computers benefit business and industry.

PERFORMANCE MEASURE
M11.1 Written or oral report, completed in accordance with instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. State the two main categories of microcomputer applications.
2. Explain and give four examples of "dedicated" control.
3. Name the five categories of general purpose microcomputers.
4. Describe the concepts of computer-aided instruction (CAI), computer-assisted drafting (CAD), and computer-integrated manufacturing (CIM).
5. Explain ways the use of computers benefits business and industry.

DUTY AREA
11. APPLYING COMPUTER TECHNOLOGY

COURSE
Electronics II (8537)
Microprocessor Application I (ETR 261)

TASK / COMPETENCY
11.2 Interface peripheral equipment.

PERFORMANCE OBJECTIVE
P11.2 Given access to a microcomputer, peripheral equipment (printer, drive, monitor, scanning devices, mouse, light pen, etc.), and operating manuals, interface peripheral equipment with the computer by following instructions in operating manuals to make system fully functional.

PERFORMANCE MEASURE
M11.2 Demonstration, all procedures in accordance with manufacturers' operating manuals and all components in system fully functional

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Match terms related to peripherals with the correct definitions.
2. Explain printer interfacing modes.
3. List differences among dot matrix, ink jet, laser, and daisy wheel printers.
4. Explain "handshaking" protocol.
5. Compare floppy disk and hard disk drives.
6. Solve a cable configuration problem.
7. Discuss common interfacing problems.

DUTY AREA
11. APPLYING COMPUTER TECHNOLOGY

COURSE
Electronics II (8537)
Microprocessor Application I (ETR 261)

TASK / COMPETENCY
11.3 Identify characteristics of various information storage systems.

PERFORMANCE OBJECTIVE
P11.3 Given necessary resources, identify characteristics of various information storage systems by explaining the operation of static and dynamic memory elements, the operation of read-only memories, memory organization and size, the operation of magnetic bubble memory and magnetic tape memory, and the format of a floppy disk.

PERFORMANCE MEASURE
M11.3 Instructor-prepared worksheet, all items rated acceptable according to instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Name the two basic types of semiconductor storage elements.
2. Explain the operation of static and dynamic memory elements.
3. Identify the types of read-only memories (ROMs) and explain their operation.
4. Explain memory organization and memory size.
5. Name three current applications of ROMs as mass-storage devices.
6. Describe the operation of magnetic bubble memory (MBM).
7. Explain the use of magnetic tape memory.
8. Draw the format of a floppy disk.

DUTY AREA
11. APPLYING COMPUTER TECHNOLOGY

COURSE
Microprocessor Applications I (ETR 261)

TASK / COMPETENCY
11.4 Write and debug a software problem.

PERFORMANCE OBJECTIVE
P11.4 Given a specified software problem, write and debug the problem by formulating a plan to solve the software problem, writing the logic flow chart for the problem, writing the program, debugging the program, and verifying the proper operation of the program.

PERFORMANCE MEASURE
M11.4 Demonstration, all steps in accordance with instructor's guidelines and program fully operational

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss logical approaches to solving software problems.
2. Apply logic diagrams to problems.
3. Demonstrate inputting and debugging a problem.
4. Demonstrate methods used to debug different types of software problems.
5. Develop a troubleshooting plan.
6. Perform operational checks.

DUTY AREA
11. APPLYING COMPUTER TECHNOLOGY

COURSE
Microprocessor Application II (ETR 262)

TASK / COMPETENCY
11.5 Troubleshoot a digital computer and peripherals.

PERFORMANCE OBJECTIVE
P11.5 Given a defective computer system with peripherals (monitor, disk drive, CRT, and printer), instruction, and equipment, troubleshoot the digital computer and peripherals by isolating the problem to the defective peripheral or to the defective board in the computer, replacing the defective peripheral or board, and performing operational checks.

PERFORMANCE MEASURE
M11.5 Demonstration, all steps completed in accordance with instructor's guidelines and computer system fully functional

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain techniques of troubleshooting a computer system to isolate a problem to the computer or to one of its peripherals.
2. Discuss techniques to identify the defective board in the computer system or peripheral.
3. Describe problems in the computer, the peripherals, and their systems.
4. Replace defective boards.

DUTY AREA
11. APPLYING COMPUTER TECHNOLOGY

COURSE
Microprocessor Application II (ETR 262)

TASK / COMPETENCY
11.6 Identify computer architecture.

PERFORMANCE OBJECTIVE
P11.6 Given schematics of several computer systems, identify computer architecture by drawing the architecture of the systems. Drawings must include memory system architecture, I/O system architecture, CPU and BUSS architecture, and system architecture.

PERFORMANCE MEASURE
M11.6 Student-produced drawings, all items matching manufacturer's or instructor's diagrams

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Describe the following:
   a. computer memory system architecture
   b. computer I/O system architecture
   c. CPU architecture
   d. BUSS architecture
   e. system architecture.
2. Discuss the uses of computer architecture diagrams.
3. Draw architectural diagrams from several different schematics.

DUTY AREA
11. APPLYING COMPUTER TECHNOLOGY

COURSE
Microprocessor Application II (ETR 262)

TASK / COMPETENCY
11.7 Develop data collection applications.

PERFORMANCE OBJECTIVE
P11.7 Given a computer system with appropriate I/O capabilities and access to hardware necessary to interconnect the computer system to data to be collected, develop data collection applications by developing the basic software and selecting the hardware necessary to collect the data.

PERFORMANCE MEASURE
M11.7 Demonstration, all items meeting industry standards for data collection techniques

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss factors to be considered in software development and hardware selection for data collection.
2. Identify hardware necessary to collect various forms of data.
3. Describe software necessary to collect and organize data in a meaningful format.
4. Apply selected hardware and software to an actual data collection task.

DUTY AREA
11. APPLYING COMPUTER TECHNOLOGY

COURSE
Programmable Controllers (ELE 239)

TASK / COMPETENCY
11.8 Apply programmable controls.

PERFORMANCE OBJECTIVE
P11.8 Given a programmable logic controller, a predetermined program, and the necessary materials and test equipment, apply programmable controls by installing and programming the controller to execute all required commands.

PERFORMANCE MEASURE
M11.8 Demonstration, all items in accordance with instructor's guidelines and controller fully functional

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Demonstrate programming a programmable logic controller.
2. Debug a faulty programmable logic controller.
3. Discuss applications of programmable controllers.
4. Make changes to programs.
5. Develop a program to meet a specified requirement.

DUTY AREA
11. APPLYING COMPUTER TECHNOLOGY

COURSE
Introduction to Computer Programming (EGR 127)

TASK / COMPETENCY
11.9 Apply standard computer operating procedures.

PERFORMANCE OBJECTIVE
P11.9 Given access to a computer system with the hardware required for backup, apply standard computer operating procedures by backing up and documenting the software on the computer system.

PERFORMANCE MEASURE
M11.9 Demonstration, all procedures meeting industry standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss the need for backup and documentation.
2. Identify different backup hardware and procedures.
3. Describe standards for backup and documentation.
4. Back up and document a computer system daily for a minimum of one week.

DUTY AREA
11. APPLYING COMPUTER TECHNOLOGY

COURSE
Microprocessor Application I (ETR 262)

TASK / COMPETENCY
11.10 Troubleshoot serial and parallel communications networks.

PERFORMANCE OBJECTIVE
P11.10 Given access to a computer system that uses serial and parallel communication peripherals and appropriate hardware, software, and tools, troubleshoot serial and parallel communications networks to discover the defective hardware or software, replace the defective hardware or reload the software, and verify that the communication channel is functional.

PERFORMANCE MEASURE
M11.10 Demonstration, all steps completed in accordance with instructor's guidelines and results matching those of the instructor

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain serial and parallel communications protocols.
2. Describe standard cables and connectors for serial and parallel communications.
3. List software and hardware tools for troubleshooting serial and parallel communications networks.
4. Develop and apply troubleshooting procedures.
5. List symptoms, defects, and repair procedures.
6. Explain methods to verify operation.

DUTY AREA
11. APPLYING COMPUTER TECHNOLOGY

COURSE
Logic Circuits and Systems I (ETR 206)

TASK / COMPETENCY
11.11 Construct a computer.

PERFORMANCE OBJECTIVE
P11.11 Given information and hardware necessary to construct a computer, and the firmware necessary to verify proper operation, construct a computer that is operational. Construction must include drawing a system block diagram, designing and fabricating a PC board, and demonstrating electronic-system layout (packaging) techniques.

PERFORMANCE MEASURE
M11.11 Student-produced computer, all components constructed according to instructor's guidelines and computer fully operational

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Describe the basic components of a computer system.
2. Draw a system block diagram based on information provided.
3. Describe hardware conflicts in computer systems.
4. Design and fabricate a PC board (P9.5).
5. Make wire wrap connections (P9.8).
6. Demonstrate sheet metal fabrication and finishing techniques (P9.10).
7. Demonstrate electronic-system layout (packaging) techniques (P9.7).
8. Verify computer operation, using firmware.
9. Solve interconnection problems.
10. Write and debug a software problem (P12.4).
11. Troubleshoot a digital computer and peripherals (P12.5).
12. Identify computer architecture (P12.6).
13. Troubleshoot serial and parallel communications networks (P12.10).

DUTY AREA
11. APPLYING COMPUTER TECHNOLOGY

COURSE
Introduction to Computer Programming (EGR 127)

TASK / COMPETENCY
11.12 Write a program in a higher order language.

PERFORMANCE OBJECTIVE
P11.12 Given a software problem, write a program in a higher order language by writing a program in QBASIC to solve the problem and accomplish the task.

PERFORMANCE MEASURE
M11.12 Student-produced program, fully able to solve the problem and accomplish the task and rated acceptable based on instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Become familiar with operating a computer.
2. Write flow charts for programs.
3. Write parts of programs.
4. Write programs with different parameters used like sequential files and functions.
5. Write programs to solve given problems.

DUTY AREA 12. APPLYING ELECTRONIC COMMUNICATIONS TECHNOLOGY

12.1 Calculate decibel power gain and decibel voltage gain.
12.2 Troubleshoot opto-electronic devices.
12.3 Analyze impedance matching networks.
12.4 Identify types of transmitters.
12.5 Describe types of modulation.
12.6 Identify types of receivers.
12.7 Identify government regulations applicable to the operation of receivers and transmitters.
12.8 Troubleshoot transmitters and receivers.
12.9 Analyze microwave receivers and transmitters.
12.10 Construct receiver and transmitter circuits.
12.11 Design and construct antennas and transmission lines.
12.12 Analyze wave propagation.
12.13 Analye frequency spectrums.
12.14 Measure optical systems outputs.

DUTY AREA
12. APPLYING ELECTRONIC COMMUNICATIONS TECHNOLOGY

COURSE
Electronic Communications I (ETR 241)

TASK / COMPETENCY
12.1 Calculate decibel power gain and decibel voltage gain.

PERFORMANCE OBJECTIVE
P12.1 Given an amplifier and the input and output power and voltage specifications, calculate the decibel power gain and the decibel voltage gain. Calculations should include conversion of dB voltage gain to dB power gain and the use of dBm. Calculated values must be within 1% of those of the instructor.

PERFORMANCE MEASURE
M12.1 Instructor-prepared test, all calculations within 1% of instructor-calculated values

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Define *decibel* (dB).
2. Explain how to calculate the power gain of an amplifier.
3. Use the power gain equation to prove theory.
4. Describe how the dB power changes as the power increases by a factor of 2 and 10.
5. Explain how a loss in power gain (attenuation) is expressed in decibels.
6. Explain why the total dB power gain is equal to the sum of the individual dB powers.
7. Explain how voltage gain can be converted to dB power gain.
8. Develop a table that will show the relationship between dB power gain and dB voltage gain.
9. Explain dBm, dBm standards, their meaning, their advantage, and where they are used.
10. Solve several problems using dB and dBm.

DUTY AREA
12. APPLYING ELECTRONIC COMMUNICATIONS TECHNOLOGY

COURSE
Electronic Communications I (ETR 241)

TASK / COMPETENCY
12.2 Troubleshoot opto-electronic devices.

PERFORMANCE OBJECTIVE
P12.2 Given manufacturers' literature, test equipment, and several opto-electronic devices, troubleshoot the opto-electronic devices by determining the devices' specifications from manufacturers' literature, using test equipment, and restoring devices to operating condition.

PERFORMANCE MEASURE
M12.2 Demonstration, all steps completed in accordance with instructor's guidelines and devices fully operational

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss the basic operation of solid state light emitting devices and solid state light sensitive devices including LEDs, solar cells, photo resistors, photo detectors, opto-couplers, photo interruptors, and lasers.
2. Apply manufacturers' literature to determine specifications of opto-electronic devices.
3. Use appropriate test equipment to measure the parameters of opto-electronic devices.
4. Identify replacement opto-electronic devices based on parameter comparison.

DUTY AREA
12. APPLYING ELECTRONIC COMMUNICATIONS TECHNOLOGY

COURSE
Electronic Communications I (ETR 241)

TASK / COMPETENCY
12.3 Analyze impedance matching networks.

PERFORMANCE OBJECTIVE
P12.3 Given several systems in which there is a fixed *Z* source matched to a fixed *KZ (K1)* load, analyze impedance matching networks as to type, impedance transformations ratio, and equations involved for each network. All measurements must be within 10% of the values specified by the manufacturer.

PERFORMANCE MEASURE
M12.3 Instructor-prepared test, all measurements within 10% of the manufacturer's values

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss types of impedance matching networks.
2. Solve equations used in impedance matching networks.
3. Measure the characteristics of impedance matching networks.
4. Analyze several impedance matching networks as to application, design, and characteristics.

DUTY AREA
12. APPLYING ELECTRONIC COMMUNICATIONS

COURSE
Electronic Communications I (ETR 241)

TASK / COMPETENCY
12.4 Identify types of transmitters.

PERFORMANCE OBJECTIVE
P12.4 Given several different types of transmitters or schematics for several transmitters, identify types of transmitters by determining all major transmitter parameters. Identification should include determination of modulation type, power level, frequency, class, and use.

PERFORMANCE MEASURE
M12.4 Instructor-prepared test, all parameters determined with 100% accuracy according to manufacturer's data

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Explain the differences between AM, FM, and pulse transmitters.
2. Describe methods for identifying different types of modulation.
3. Identify characteristics of mobile and fixed transmitters.
4. Determine the power level of transmitters.
5. Use manufacturer's literature to determine the following:
   a. modulation type
   b. power level
   c. frequency
   d. class
   e. use

DUTY AREA
12. APPLYING ELECTRONIC COMMUNICATIONS TECHNOLOGY

COURSE
Electronic Communications I (ETR 241)

TASK / COMPETENCY
12.5 Describe types of modulation.

PERFORMANCE OBJECTIVE
P12.5 Given a representative AM spectrum, a representative FM spectrum, and a representative pulse modulated waveform spectrum, describe types of modulation. Descriptions should include calculation of percent of modulation, calculation of number of significant sidebands and their levels, and the similarities between FM and phase modulation.

PERFORMANCE MEASURE
M12.5 Instructor-prepared test, all items described in accordance with industry definitions

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Describe AM modulation.
2. Calculate percent of modulation in AM.
3. Draw an AM spectrum, given f_o, modulation frequency, and percent of modulation.
4. Describe FM modulation.
5. Calculate percent of modulation based on deviation.
6. Calculate number of significant sidebands and their levels.
7. Draw an FM spectrum, given modulation index and modulating frequency.
8. Describe pulse modulation.
9. Draw a representative spectrum of a pulse modulated waveform.
10. Describe the similarities between FM and phase modulation.

DUTY AREA
12. APPLYING ELECTRONIC COMMUNICATIONS TECHNOLOGY

COURSE
Electronic Communications I (ETR 241)

TASK / COMPETENCY
12.6 Identify types of receivers.

PERFORMANCE OBJECTIVE
P12.6 Given manufacturers' literature and several receivers, identify the receivers as to frequency range, application, modulation types, mobile or fixed base, power requirements, and reception bandwidth. All receiver parameters must be identified with at least 80% accuracy according to data specified by the manufacturer.

PERFORMANCE MEASURE
M12.6 Instructor-prepared test, all receiver parameters identified with at least 80% accuracy according to manufacturers' data

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify receiver controls.
2. Discuss types of demodulators.
3. Use manufacturers' literature to determine receiver types.
4. List differences between fixed and mobile receivers.
5. Discuss differences between receivers and transceivers.

DUTY AREA
12. APPLYING ELECTRONIC COMMUNICATIONS TECHNOLOGY

COURSE
Electronic Communications I (ETR 241)

TASK / COMPETENCY
12.7 Identify government regulations applicable to the operation of receivers and transmitters.

PERFORMANCE OBJECTIVE
P12.7 Given a copy of the FCC rules and regulations, identify government regulations applicable to the operation of receivers and transmitters with at least 90% accuracy. Identification should include sources of FCC rules, types of operations requiring licenses, and types and privileges of various FCC licenses.

PERFORMANCE MEASURE
M12.7 Instructor-prepared test, all rules and regulations identified with at least 90% accuracy

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss sources for FCC rules and regulations.
2. List rules for operation of transmitters.
3. List rules for operation of receivers.
4. Identify types of operations that require a license.
5. List the types of FCC licenses and privileges of each license with respect to receiver and transmitter operation.

DUTY AREA
12. APPLYING ELECTRONIC COMMUNICATIONS TECHNOLOGY

COURSE
Electronic Communications I (ETR 241)

TASK / COMPETENCY
12.8 Troubleshoot transmitters and receivers.

PERFORMANCE OBJECTIVE
P12.8 Given test equipment, replacement parts, manufacturers' service literature, and a defective transmitter and receiver, troubleshoot the receiver and transmitter to locate the defective section, identify the defective component, replace the defective component, and verify proper operation.

PERFORMANCE MEASURE
M12.8 Demonstration, all steps completed in accordance with instructor's guidelines and equipment fully operational and meeting manufacturers' specifications

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss troubleshooting methods to narrow a problem to a particular section.
2. Describe how to locate a defective component in a defective section, using standard circuit diagnostic techniques.
3. Analyze receiver and transmitter circuits.
4. Use VOMs, oscilloscopes, power meters, etc., for troubleshooting.
5. Replace defective components (P9.2).
6. Disassemble and reassemble transmitter and receiver chassis.
7. Verify operation of receivers and transmitters to manufacturers' specifications.

DUTY AREA
12. APPLYING ELECTRONIC COMMUNICATIONS TECHNOLOGY

COURSE
Electronic Communications I (ETR 241)

TASK / COMPETENCY
12.9 Analyze microwave receivers and transmitters.

PERFORMANCE OBJECTIVE
P12.9 Given a microwave transmitter and receiver, analyze the receiver and transmitter by locating all major sections and explaining the operation of each. Analysis should include descriptions of how the local oscillator frequency is developed in microwave receivers, how frequency and power are developed in microwave transmitters, and how frequency and power are measured.

PERFORMANCE MEASURE
M12.9 Instructor-prepared test, all aspects of the equipment described in accordance with manufacturers' data

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss the differences between low frequency receivers and transmitters and microwave receivers and transmitters.
2. Describe how the local oscillator frequency is developed in microwave receivers.
3. Explain how the frequency and power are developed in a microwave transmitter.
4. List methods of heterodyning microwave frequencies to IF frequencies.
5. Identify all major blocks of microwave receivers and transmitters.
6. Describe the test equipment and methods used to measure frequency and power at microwave frequencies.

DUTY AREA
12. APPLYING ELECTRONIC COMMUNICATIONS TECHNOLOGY

COURSE
Electronic Communications I (ETR 241)

TASK / COMPETENCY
12.10 Construct receiver and transmitter circuits.

PERFORMANCE OBJECTIVE
P12.10 Given necessary tools and supplies, construct receiver and transmitter circuits to meet industry-accepted standards. Construction techniques should include applying schematic diagrams, soldering components, interconnecting posts, cutting and dressing leads, identifying polarity and correct placement of components, and demonstrating electronic-system layout techniques.

PERFORMANCE MEASURE
M12.10 Student-produced receiver and transmitter, all components meeting industry standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Apply schematic diagrams.
2. Solder components to printed circuit boards (P9.2).
3. Interconnect posts by wire wrapping.
4. Cut and dress leads.
5. Identify electronics hardware.
6. Identify polarity and correct placement of components.
7. Use protype boards.
8. Demonstrate electronic-system layout techniques (P9.7).

DUTY AREA
12. APPLYING ELECTRONIC COMMUNICATIONS TECHNOLOGY

COURSE
Electronic Communications I (ETR 241)

TASK / COMPETENCY
12.11 Design and construct antennas and transmission lines.

PERFORMANCE OBJECTIVE
P12.11 Given materials and antenna and transmission line parameters, design and construct antennas and transmission lines. The antenna should be constructed in the HF to VHF frequency range in accordance with industry-accepted practices, and the balanced or unbalanced transmission line should be constructed to match the antenna in accordance with industry-standard *Z* equations.

PERFORMANCE MEASURE
M12.11 Student-designed and constructed antenna and transmission line, all components meeting industry standards

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss antenna types and their gain, *Z*, bandwidth, polarization, and physical size.
2. Construct a reference antenna.
3. Measure *Z*, bandwidth, gain, and beamwidth of an antenna.
4. Measure SWR of an antenna.
5. Solve *Z* equations of a transmission line.
6. Discuss antenna design with respect to frequency.
7. Discuss antenna design with respect to physical size of the antenna.
8. Describe physical loss and size limitations of balanced and unbalanced transmission lines.
9. Design an antenna in the HF to UHF range.
10. Design a transmission line for a particular *Z*.

DUTY AREA
12. APPLYING ELECTRONIC COMMUNICATIONS TECHNOLOGY

COURSE
Electronic Communications I (ETR 241)

TASK / COMPETENCY
12.12 Analyze wave propagation.

PERFORMANCE OBJECTIVE
P12.12 Given industry-accepted theories and information, analyze wave propagation at LF, HF, VHF, UHF, and microwave frequencies. Analysis must make use of the concepts of line of sight propagation, skip, omnidirectional/directional propagation, polarization, and ionospheric reflection/penetration/absorption.

PERFORMANCE MEASURE
M12.12 Instructor-prepared test, all aspects of analysis in agreement with industry-accepted theory

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Describe line of sight propagation.
2. Describe skip and the relationship of skip to frequency.
3. Identify omnidirectional vs. directional propagation.
4. Identify types of polarization.
5. Relate frequency as to ionospheric reflection, penetration, or absorption.

DUTY AREA
12. APPLYING ELECTRONIC COMMUNICATIONS TECHNOLOGY

COURSE
Electronic Communications I (ETR 241)

TASK / COMPETENCY
12.13 Analyze frequency spectrums.

PERFORMANCE OBJECTIVE
P12.13 Given a spectrum analyzer and signal generators capable of AM, FM, and pulse modulation, anayze the frequency spectrums by predicting and displaying each type of spectrum in accordance with the spectrum analyzer's instruction manual.

PERFORMANCE MEASURE
M12.13 Instructor-prepared test, frequency spectrums predicted and displayed in accordance with instructor's analysis

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Use spectrum analyzer (P5.14).
2. Discuss AM, FM, and pulse spectrums frequency distribution.
3. Discuss AM, FM, and pulse spectrums levels.
4. Explain Bessell functions.
5. Demonstrate application of a spectrum analyzer to narrow band and wide band spectrum displays.
6. Predict and display AM, FM, and pulse waveforms.
7. Analyze transmission spectrums.

DUTY AREA
12. APPLYING ELECTRONIC COMMUNICATIONS TECHNOLOGY

COURSE
Electronic Communications I (ETR 241)

TASK / COMPETENCY
12.14 Measure optical systems outputs.

PERFORMANCE OBJECTIVE
P12.14 Given information and test equipment, measure optical systems output. Measuring techniques must include use of manufacturers' literature, use of safety precautions, and selection of appropriate test equipment.

PERFORMANCE MEASURE
M12.14 Instructor-prepared test, all measurements performed in accordance with standard industry practices

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Identify the various types of optical systems.
2. Use manufacturers' literature to determine the output of optical systems.
3. Discuss safety practices when measuring the output of optical systems.
4. Select appropriate test equipment to measure the output of optical systems.

DUTY AREA 13. APPLYING INDUSTRIAL CONTROLS SYSTEMS

13.1 Draw the I-V characteristics of a silicon-controlled rectifier (SCR).
13.2 Troubleshoot feedback control systems.
13.3 Troubleshoot AC/DC drive systems.
13.4 Building manufacturing systems utilizing programmable logic controllers.

DUTY AREA
13. APPLYING INDUSTRIAL CONTROL SYSTEMS

COURSE
Industrial Electronics I (ETR 237)

TASK / COMPETENCY
13.1 Draw the I-V characteristics of a silicon-controlled rectifier (SCR).

PERFORMANCE OBJECTIVE
P13.1 Given an SCR and the necessary equipment, draw the I-V characteristics of the SCR for three values of a gate current, and label all important points. The characteristic should show a decrease in anode to cathode voltage as the gate current increases when switching from off to on.

PERFORMANCE MEASURE
M13.1 Student-produced drawings, all items in accordance with instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Define *thyristor.*
2. Explain how thyristors differ from bipolar transistors and FETS, and state their main applications.
3. Draw the schematic diagram for an SCR, and explain the method used to turn it on and off.
4. Explain one method used to reduce the effect of switching transients in SCRs.
5. Explain what is meant by an SCR crowbar, and state one application of the SCR crowbar.
6. Explain the operation of a photo-SCR (LASCR), and draw a schematic diagram illustrating one application of an LASCR.
7. Draw the schematic symbol for a GCS and an SCS, and define the meaning of each term.
8. List two bidirectional thyristors, draw the schematic symbols for each, and state several applications for each.
9. Determine how gate current is used to switch an SCR on and off.

DUTY AREA
13. APPLYING INDUSTRIAL CONTROL SYSTEMS

COURSE
Programmable Controllers (ELE 239)

TASK / COMPETENCY
13.2 Troubleshoot feedback control systems.

PERFORMANCE OBJECTIVE
P13.2 Given test equipment, manufacturer's literature, and a defective feedback control system, troubleshoot the feedback control system to identify the defective section of loop, determine the location of failure in feedback control system, repair defective component, and verify operation of system to manufacturer's specifications.

PERFORMANCE MEASURE
M13.2 Demonstration, all steps completed in accordance with instructor's guidelines and system operational and calibrated to manufacturer's specifications

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Determine where to break a loop and inject test signals.
2. Use test equipment to localize feedback loop problem.
3. Discuss problems that static and dynamic feedback can cause.
4. Determine effects of poor and excessive loop gain.
5. Use test equipment to verify a defect in a component.
6. Calibrate a feedback control loop to manufacturer's specifications.

DUTY AREA
13. APPLYING INDUSTRIAL CONTROL SYSTEMS

COURSE
Programmable Controllers (ELE 239)

TASK / COMPETENCY
13.3 Troubleshoot AC/DC drive systems.

PERFORMANCE OBJECTIVE
P13.3 Given test equipment, AC and DC drive systems, and manufacturer's literature, troubleshoot AC/DC drive systems to isolate the defect to the power source, drive system, or drive motor; replace the defective component; and verify operation to manufacturer's specifications.

PERFORMANCE MEASURE
M13.3 Demonstration, all steps completed in accordance with instructor's guidelines and systems fully operational and repaired to manufacturer's specifications

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Discuss the differences between AC and DC drive systems.
2. Draw block diagrams of common AC and DC drive systems.
3. Select appropriate test equipment to troubleshoot power supplies, drive electronics, and drive motors.
4. Identify AC, DC, phase, and stepping motors and their electrical requirements.
5. Identify appropriate tools to repair AC and DC drive systems.
6. Verify proper operation of AC and DC drive systems by using manufacturers' literature.
7. Discuss typical defects in AC or DC drive systems.

DUTY AREA
13. APPLYING INDUSTRIAL CONTROL SYSTEMS

COURSE
Programmable Controllers (ELE 239)

TASK / COMPETENCY
13.4 Build manufacturing systems utilizing programmable logic controllers.

PERFORMANCE OBJECTIVE
P13.4 Given the required sensors, motors, and other hardware, build manufacturing systems utilizing programmable logic controllers. Demonstration must include programming systems with the PLC, including necessary wiring and modifications.

PERFORMANCE MEASURE
M13.4 Student-built systems, all components in accordance with instructor's guidelines

ENABLING OBJECTIVES / LEARNING ACTIVITIES
1. Program ladder diagrams on the PLC.
2. Program the PLC from control circuits.
3. Program a hand-held terminal project.
4. Program a computer project for the PLC.
5. Wire PLC to conveyor and other systems.

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